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FIRE FIGHTERS' FITNESS TRAINING EVALUATION

by

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A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled FIRE FIGHTERS' FITNESS TRAINING EVALUATION submitted by JOHN D. BALESHTA in partial fulfillment of the requirements for the degree of Master of Science in Physical Education.

DEDICATION

To my mother for her prayers and my father for his example

ABSTRACT

Fifty-six male fire fighter recruits ($\overline{X}$ age = 23.5 years) from the Edmonton Fire Department participated in this study. The subjects were tested before a nine week physical training and lifestyle educational program, after the nine week program, and after a nine week period of detraining. The test battery included: functional performance tests, body composition assessment, and a lifestyle knowledge test. During the nine weeks of training, statistically significant positive changes were observed in the $\dot{V}O_2max$, shuttle run, percent body fat, and knowledge questionnaire results. There was a significant negative change in the standing long jump test. The nine week period of detraining produced a significant increase in both the shuttle run time and the standing long jump distance. It was concluded that the nine week training program was beneficial in eliciting positive fitness changes that did not significantly decrease in the nine week detraining period.

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CHAPTER I

INTRODUCTION

Fire fighting has been shown to be an occupation requiring near maximal cardiac exertions for extended periods of time (Lemon and Hermiston, 1977). The physical attributes of a fire fighter must be of a sufficient magnitude to effectively withstand these intense demands. Unfortunately, the overall sedentary nature of the job is not condusive to an optimal level of cardiovascular fitness (Vincent and Knowles, 1979).

The United States Department of Health, Education and Welfare reported that the death rate for all cardiovascular disease was higher in fire fighters than any other occupation (Barnard, 1979). Heart attacks and strokes accounted for 44 percent (%) of all fire fighter deaths in the United States in 1977 (Washburn and Harlow, 1977). Barnard (1975) found a greater ischemic response in fire fighters to near maximal exercise, than in a group of insurance underwriters. Collectively, this evidence was alarming because fire fighters were generally well screened by medical examinations and physical fitness tests before entering the fire department.

Blimkie et al. (1977) compared the heart rate and catecholamine response of fire fighters to a real and mock alarm. They discovered that the immediate response was of intense physical arousal. A sudden strenuous effort within the benefit of a preliminary warm-up has also been found to elicit ischemic cardiovascular responses in healthy men (Barnard et al., 1975). Davis and Santa Maria (1974) reported that the energy cost of wearing heavy clothing and equipment was another factor that reduced the effectiveness of the fire fighter. They found that a 164 pound man wearing 52 pounds of equipment required a 33% increase in energy

expenditure to perform a moderate amount of work.

Due to the strenuous nature of their job, fire fighters should maintain a high level of physical fitness (Peabody, 1976). Davis and Santa Maria (1975) found that most of the fire fighters examined were within the normal range of physical fitness for the North American population. However, the average American male was considered to be unfit and incapable of effectively fighting fires (Lemon and Hermiston, 1977). The maximum oxygen uptake observed was in the vicinity of 40 milliliters per kilogram of body weight per minute ($ml.kg^{-1}.min^{-1}$). The recommended $\dot{V}O_2max$ was 45 $ml.kg^{-1}.min^{-1}$ or better to meet the demands of fire fighting (Davis and Santa Maria, 1975).

Davis et al. (1982) examined the ability of fire fighters to perform simulated fire fighting tasks. The high heart rates in this study indicated that the average aerobic capacity of the fire fighters was inadequate to complete typical fire fighting tasks.

The poor physical fitness levels demonstrated by fire fighters that have been studied, creates a need for physical training programs. Physical training programs have been found to elicit appreciable changes in $\dot{V}O_2max$ and body composition (Wenger, 1976; and Milesis et al., 1975). Hickson (1976) observed a 44% increase in $\dot{V}O_2max$ (36.6 to 55.4 $ml.kg^{-1}.min^{-1}$) as a result of an eight week high intensity training program. Once a desired level of fitness was reached, it could be maintained by fewer exercise periods per week if the intensity was not reduced (Brynteson and Sinning, 1973). Vogel (1978) trained 254 army recruits for three months and found a slight increase in body weight, an 8.6% decrease in body fat and a 1.1 kilogram (kg) increase in lean mass.

The importance of physical fitness in relation to the occupation of fire fighting is multi-faceted. Although there is no conclusive

evidence that exercise will decrease the chance of a heart attack, the American Heart Association has taken the position that it is at least prudent to exercise (Zohman, 1974). Limited evidence suggests that a physical training program will help to decrease the chance of having a fatal heart attack and will enhance the recovery process from a heart attack. The most beneficial effect of a physical training program is the enhanced capacity of a fire fighter to accomplish strenuous occupational tasks. For example, a fire fighter will be able to perform a given amount of work with reduced cardiovascular stress if a high level of physical fitness exists. Other benefits from training include: a delay in the onset of fatigue and a more rapid recovery rate both of which will decrease the fire fighter's susceptibility to accidents (Peabody, 1976). Finally, fire fighters may perform better due to an increased self-esteem which often results from being physically able to handle difficult physical tasks (Wilson, 1973).

The evidence of cardiovascular disease and the poor physical fitness of the average fire fighter was the justification for the following study.

The Edmonton Fire Department in conjunction with the Faculty of Physical Education of the University of Alberta, developed and implemented a nine week physical training and lifestyle education program (Quinney, 1981). The objectives of the program were as follows:

> To develop and/or maintain a high level of physical fitness.
>
> To promote an active and prudent lifestyle which will maintain the high level of physical fitness required for their occupation.
>
> To increase the fire fighter recruit's knowledge about the components of physical fitness and the appropriate methods of maintaining a high level of personal fitness.

The training program incorporated the components necessary to develop

fitness as it would apply to the work stresses involved in the demands of fire fighting. The program was divided into four phases: warm-up and flexibility exercises, circuit training for muscular strength and endurance, aerobic endurance, and cool-down exercises. The program was designed to include some basic training principles:

> The training duration was for one hour per day, five days per week, for nine weeks.
>
> The aerobic endurance component was emphasized due to its importance in cardiovascular health and the ability to rest fatigue.
>
> The inclusion of flexibility, warm-up, and cool-down phases allowed the physiological system to adapt gradually to the increase and decrease in the exercise stress.
>
> Individuals were assigned exercise intensity, duration, and frequency prescriptions whenever possible.
>
> The exercise routines did not require any elaborate equipment or facilities.

Resource people in the areas of exercise physiology, nutrition, workman's compensation, stress management, and psychology lectured on lifestyle modification. This facet of the program was expected to enhance the fire fighters' professional effectiveness and enjoyment of their personal lifestyles. The educational topics were as follows: components of fitness and principles of training; development of a personal fitness program; nutrition and weight control; body mechanics; posture and care of the back; physical and psychological demands of fire fighting; lifestyle and health risk; and personal lifestyle planning for fire fighters.

STATEMENT OF THE PROBLEM

The major purpose of this study was to determine the effectiveness

of a nine week training program in improving the fitness level of fire fighter recruits. A secondary purpose was to determine the degree of retention of fitness after a nine week period of detraining. Finally, an attempt was also made to ascertain knowledge and awareness changes during the nine weeks of lifestyle education and its retention over the nine week period of detraining.

LIMITATIONS

1. Motivation could not be controlled in the testing sessions.
2. It was not possible to examine the subjects at the same time period for all three tests.
3. The sample size was limited to the fire fighters who were willing to return for a third test.
4. It was not feasible to use a control group in this study.

DELIMITATIONS

1. The subjects were delimited to 56 male fire fighter recruits from the Edmonton Fire Department.
2. Class 83 (n = 24) was tested on functional-performance, percent body fat changes, and knowledge retained. Class 84 (n = 32) was tested on percent body fat changes and knowledge gained.
3. The functional performance test battery was delimited to the tests designed by the Faculty of Physical Education, University of Alberta.

DEFINITION OF TERMS

1. Maximum oxygen uptake and maximal aerobic power are used synonymously and both refer to an individual's maximum capacity to consume, transport, and utilize oxygen.

2. Detraining is a period of no formal training.

3. Functional-performance tests are the battery of tests used to determine the physical fitness changes.

CHAPTER II

REVIEW OF LITERATURE

This literature review has been delimited to the research relevant to the statement of the problem, the justification of the study, and the techniques used in the collection of the data.

CARDIOVASCULAR STRESS OF FIRE FIGHTING

Incidence of Cardiovascular Disease in Fire Fighters

There are numerous hazards associated with the occupation of fire fighting. Some of these include: smoke inhalation, burns, building collapse, toxic chemical exposure, and electrocution (Washburn, 1975). However, the greatest cause of on-the-job fire fighter death is cardiovascular disease (Peabody, 1976).

A statistical report by the United States Department of Health, Education and Welfare showed that the death rate for all cardiovascular diseases, and in particular atherosclerotic heart disease, was higher in fire fighters than in public officers, longshoremen, lumbermen, construction workers, smelters, and furnacemen (Barnard, 1979). The death rates for the age groups 55 to 59 and 60 to 64 years were twice as high in fire fighters than the average for all the other groups. Washburn and Harlow (1977) reported that in the United States in 1977, the leading cause of fatal injury in fire fighters was stress resulting from heart attacks, or stroke, accounting for 44 percent (%) of all deaths. The International Association of Fire Fighters investigated 101 on duty deaths between September 22, 1974 and December 31, 1975 and discovered that 45 of these deaths were related to heart attacks (McClennan, 1976). These statistics are alarming because fire fighters are generally considered to be a

select group.

From January 1971 through December 1977, Thomas et al. (1979) compiled data on 13,000 initial and periodic resting and exercise examinations of coronary symptom free male lifeguards, fire fighters, and law enforcement personnel in Los Angeles County. They then employed a predictive cardiac risk index to assess the chances of 4,066 of the initial employee examinations attaining heart disease. The components contained in the index were: age, sex, family history, blood pressure, cholesterol, weight, smoking, and exercise, all generally associated with an increased risk of heart disease. The fire fighter group (n = 1825) had 53 and 33 percent in the average and moderately high risk categories respectively.

Barnard et al. (1975) investigated the electrocardiographic (ECG) response to near maximal exercise and documented the blood pressure, serum cholesterol and smoking habits of 90 randomly selected fire fighters between the ages of 40 and 59. All the results were compared to a similar age group of insurance underwriters they previously studied. The maximum oxygen uptake ($\dot{V}O_2max$) estimated from the near maximal exercise workload was 49.9 $ml.kg^{-1}.min^{-1}$ approximately 8% greater than the insurance underwriters. Although in this case the fire fighters had a lower cardiac risk index, they had a greater evidence of ischemic heart disease as compared to the insurance underwriters. One mm of horizontal or down sloping depression of the S-T segment observed either during exercise or in the five minutes post exercise period, constituted a positive ischemic ECG response.

Although a fire fighter's daily routine is generally sedentary, their level of activity certainly exceeds many other occupations. Since a sedentary lifestyle is commonly associated with increased cardiovascular risk, why do fire fighters have higher incidences of cardiovascular

disease as opposed to less active groups? The evidence seems to suggest that the cause is linked to a combination of high emotional stress levels, poor lifestyle habits and the extreme physical requirements of fire fighting.

Response of the Cardiovascular System to Fire Fighting

Fire fighters are often required to work at extremely high heart rates for extended periods of time. Barnard and Duncan (1975) studied the heart rate response of fire fighters during a normal 24 hour work day to discover the intensity at which they worked.

The subjects were 35 fire fighters aged 23 to 42 from the Los Angeles City and County Fire Departments. Heart rates were monitored by an Avionics Model 375 Mini Recorder. Fifteen to 30 seconds after the alarm, a mean increase of 47 beats/minute (bpm) was observed. While on route to the fire the heart rates remained on the average, 30 bpm higher than that recorded before the alarm. During the actual fire fighting a few men exhibited extreme heart rates for prolonged periods of time. One fire fighter had an average heart rate of 188 bpm for 15 minutes during the initial stages of a structural fire. Movement artifact may have made some of these responses slightly erroneous, however, it was evident that the cardiovascular system was often under immense physical stress. The high heart rate responses to the alarms and the actual fire fighting was attributed to increased anxiety coupled with heavy work in a hot environment.

One study attempted to separate the physical from the emotional response to the fire alarm by comparing the heart rate response to a real and mock alarm (Blimkie et al., 1977). The mock alarm was a verbal command over the public address system to which the subjects responsed as if a real fire existed. A second purpose of this study was to

describe catecholamine response to the fire alarm. The heart rate increased 66.2 bpm (83.5 to 149.7 bpm) and 43.4 bpm (70.6 to 114.1 bpm) in response to the real and mock alarms respectively. The mock alarm increase represented an 82.9% increase in the heart rate observed in the first 30 seconds of the real alarm condition. This 82.9% heart rate response was attributed to the intense physical activity displayed by the men running to their vehicles with the remaining 17.1% contributed to anxiety or other emotional factors associated with the alarm. There was a significant increase in the catecholamine levels which was comparable to the increase in heart rate in response to the real alarm. It was concluded that the majority of the response to an alarm was due to an intense physical arousal, with the emotional component having less effect.

The fire fighter's occupation often demands sudden strenuous effort without the benefit of a preliminary warm-up (Barnard et al., 1973). Activity of this nature has been found to promote sudden drastic changes in the cardiovascular system. The purpose of this study was to define the adequacy of the cardiovascular response of forty-four asymptomatic males, aged 21 to 52, exposed to a brief period of high intensity work. The high intensity work consisted of running on a treadmill at 9 miles per hour (mph) with a 30% grade for 10 seconds, without any prior warm-up. Due to movement artifact, the ECG response was only recorded immediately after the exercise bout. If the ECG was normal during the first run, the subject ran a second time for a duration of 15 seconds. The same test protocol was repeated in another phase of the study, however, this time the subjects were allowed a 2 minute jog-in-place to warm-up.

Of the 44 men who ran on the treadmill without prior warm-up, 30 (68%) had S-T segment changes in their immediate post exercise response. The duration of some of these responses ranged from a few beats to 4 minutes.

The heart rates for the individuals with abnormal responses increased from 87 to 149 bpm and were not dissimilar to normal responses. Of the 22 subjects with abnormal ECG responses who exercised a second time, this time with a warm-up, ten men had completely normal responses and ten had reduced S-T depression. Two of the subjects still had significant S-T depression.

Barnard et al. (1973) did a follow-up study to determine the cause of the abnormal ECG responses. Intra-arterial pressure and ECG's were recorded during various types of exercise in 10 asymptomatic men. The ratio of the diastolic pressure time index and the tension time index (DPTI/TTI) was used to estimate subendocardial blood flow. The intense activity was a treadmill run for 20 seconds, at 10 mph, at a 24% grade. The warm-up exercise was a standard multi-stage treadmill test, in which the subjects exercised for 2 minutes at each workload until their heart rates were near maximum for their age range.

After the sudden strenuous exercise without a prior warm-up, the ECG's of 6 subjects were abnormal. With the inclusion of the warm-up exercise, 8 subjects had normal ECG's while only 2 had minor S-T segment changes. The heart rate values were significantly higher after exercise with a prior warm-up as opposed to without a warm-up (158.3 to 164.8 bpm). The DPTI/TTI ratios for the subjects who had an abnormal ECG response to sudden exercise without prior warm-up were below .44. When the sudden exercise followed a warm-up, the 8 subjects with normal ECG's had ratios above .44.

The evidence of the previous two studies indicated that a sudden burst of high intensity exercise without prior warm-up resulted in ischemic changes in the ECG response. Pre-warm-up exercises seemed to eliminate or at least reduce this phenomenon.

The energy cost of wearing heavy clothing and equipment in hazardous environmental conditions was another factor that reduced the effectiveness of the fire fighter (Davis and Santa Maria, 1975). Fire fighters were tested walking on a motor driven treadmill, at a speed of 3.4 mph at a 4% grade for six minutes, with and without their equipment. The mean heart rates were 160 and 130 bpm respectively with corresponding mean oxygen consumption rates of 2.4 and 1.8 liters/minute. Therefore the energy cost of wearing fire fighting protective equipment was approximately one-third above the energy required to perform a moderate amount of work. The data showed that a 184 pound fire fighter wearing 52 pounds of equipment could expect an increase in energy of 33% in carrying out his duties.

The former discussion has indicated that the task of fire fighting tends to elicit high cardiovascular responses for extended periods of time. This phenomena may be one of the causes of the high incidence of cardiovascular disease in fire fighters.

Physical Fitness Level of Fire Fighters

Many of the authors have indicated that due to the strenuous nature of fire fighting, a high level of physical fitness could be a good prerequisite for all fire fighters (Peabody, 1976; Wilson, 1973; and Davis and Santa Maria, 1975).

Lemon and Hermiston (1977) assessed the physical characteristics, functional capacity, and body composition of 45 professional fire fighters aged 23 to 49 years. The average $\dot{V}O_2max$ value was 40.5 $ml.kg^{-1}.min^{-1}$. There was a tendency of all the parameters as related to physical fitness to decrease with an increase in age. Any job related training effect was not significant to delay the rate of decline of $\dot{V}O_2max$ with age. Most of

the fire fighters in this study were considered to be well within the normal range of fitness for the North American population. However, this status doesn't qualify them to be able to efficiently meet the strenuous physical requirements of fire fighting. The recommendations were that fire fighters should devote more time to develop and maintain a higher level of fitness, especially older men who still participated in routine fire fighting.

The Fire Service Extension of the University of Maryland conducted a week long Smoke Divers training course for 40 fire fighters from several east coast states (Davis and Santa Maria, 1975). Since the training was quite strenuous, all the participants were required to undertake an exercise treadmill test. The test was a treadmill walk at 34 mph, the grade of which was increased 2% every 4 minutes depending upon the heart rate observed by an ECG reading. The predicted $\dot{V}O_2max$ for the 37 subjects (n = 37) was 38.02 $ml.kg^{-1}.min^{-1}$ with a range of 24 to 49.5. Again the fitness level of the fire fighters was about the same as an average American male. In conclusion, it was felt that fire fighters should be in good condition with an average $\dot{V}O_2max$ in excess of 45 $ml.kg^{-1}.min^{-1}$ to adequately meet their job requirements.

Davis et al. (1982) examined the relationship between simulated fire fighting tasks and physical performance measures. The major objective of the study was to determine the physical profile necessary to meet the physical requirements of fire fighting. The simulated fire fighting tasks included: ladder extension, standpipe carry, hose pull, simulated rescue, and simulated forcible entry. The physical performance measures were divided into three categories: anthropometric measures, neuromuscular measures, and physiological measures at rest. The average time to complete the five simulated tasks was seven minutes. The fire fighters' average

heart rate was 168.9 bpm, or 91.8% of the maximal heart rate. It was concluded that with an additional burden of heat stress placed on the cardiovascular system, the average fire fighter's aerobic capacity was inadequate to complete typical fire fighting tasks at the pace observed in this study.

The high level of cardiovascular stress as evident by the incidence of cardiovascular disease and the strenuous nature of the fire fighting task, reinforced the importance of having well conditioned fire fighters. Unfortunately, many of the fitness studies observed did not indicate that this was the case.

EFFECTS OF ENDURANCE TRAINING, DETRAINING, AND WARM-UP EXERCISES ON THE CARDIOVASCULAR SYSTEM

There are many physiological adaptations that can occur as a direct result of physical training (Saltin, 1969; Astrand, 1976; and Clausen, 1977). The major emphasis of this section will be on cardiovascular changes with respect to physical training and detraining. The effects of warm-up exercise on the response of the cardiovascular system will also be briefly covered due to its relevance to the fire fighting task.

Maximal Oxygen Uptake

Maximal oxygen uptake ($\dot{V}O_2max$) or maximal aerobic power, may be defined as the highest oxygen uptake an individual can attain during physical work while breathing at sea level (Astrand and Rodahl, 1977). The determination of maximal oxygen uptake is a generally accepted method to quantify cardiovascular adaptations to physical training (Rowell, 1974; and Saltin and Rowell, 1980).

The contribution of central and peripheral circulatory adaptations to $\dot{V}O_2max$ has been debated by numerous authors (Rowell, 1974; Clausen, 1977;

Saltin, 1977b; and Saltin and Rowell, 1980). There was a common acceptance that both factors did limit $\dot{V}O_2max$, however there was no consensus on the relative contribution of each factor. The most noticeable influences of central and peripheral adaptations on $\dot{V}O_2max$ were an increase in maximal cardiac output ($\dot{Q}$) and an increase in arterio-venous difference, respectively (Ekblom, 1968).

In the past, it was believed that due to the stable nature of the maximum heart rate, an increase in $\dot{Q}max$ was a result of an increase in the stroke volume (Rowell, 1974). However, Clausen (1977), after examining the results of several studies that measured both $\dot{Q}$ and mean arterial pressure, postulated that a reduction in total peripheral resistance could augment maximal blood flow and increase $\dot{Q}max$. An increase in arterio-venous difference was attributed to: vasconstriction in inactive areas which increased muscle blood flow (Ekblom, 1968), increased capillary supply of skeletal muscle which allowed more time for oxygen utilization (Brodal et al., 1977) and an increased amount of muscle mitrochondria and myoglobin which increased oxygen extraction in the working muscles (Holloszy, 1975).

Prediction of Maximum Oxygen Uptake

Maximum oxygen uptake can be either directly measured from an all-out exhaustive effort, or predicted from a submaximal test. The most common exercise modes used with both methods are: the treadmill, the bicycle ergometer and the step tests. The purpose of this section is to examine the principle behind the Astrand/Ryhming submaximal bicycle ergometer test (Astrand and Ryhming, 1954).

This test relies on the premise that heart rate and $\dot{V}O_2$ are linear up to near maximal levels of work, and that all subjects under consideration are able to reach their maximal cardiac frequency for their sex and age

(Davies, 1968). In actual fact the heart rate and $\dot{V}O_2$ relationship is asymptolic in nature, that is it is only linear between the heart rates of 120 and 170 bpm. This phenomenon accounts for a 6% error in prediction of $\dot{V}O_2max$ (Astrand and Ryhming, 1954; and Keren et al., 1980).

Glassford et al. (1965) compared three direct measures of $\dot{V}O_2max$ with Astrand's predictive test. Statistical analysis showed that the intercorrelations between the four oxygen uptake tests were similar (ranged from .63 to .82). Also, the correlations obtained between the predictive test values and those obtained in the three direct tests were equivalent to those obtained in the latter tests, therefore the relationships between the predictive test and any one direct test was as good as the relationship between any two direct tests. De Vries (1965) found a correlation of .736 ($p < .01$) between the Astrand predicted test and a $\dot{V}O_2max$ test on the bicycle ergometer.

Some advantages of submaximal bicycle tests are: they are free from the error which may be introduced due to the need for motivation on the part of the subject (Burke, 1976), the danger or risk is reduced (Davis, 1968), and the energy expenditure can be predicted more accurately (Astrand and Rodahl, 1967).

Adaptations with Training

It is important to consider the relationship between increases in $\dot{V}O_2max$ and the initial level of fitness when assessing the true value of a training program. Sharkey (1970) examined pre and post physical work capacity tests with initial fitness and discovered a significant inverse relationship ($r = -.539$) with an increase in $\dot{V}O_2max$.

If the purpose of a study is to examine the increases in $\dot{V}O_2max$ as a result of different training stimuli, each training group should be

TABLE 2.1

CHANGES IN $\dot{V}O_2$MAX WITH PHYSICAL TRAINING

Author	Date	n	Mode	Total Training (weeks)	Frequency (days/week)	$\dot{V}O_2max$ $ml.kg^{-1}.min^{-1}$ Pre	Post	Change %	Significance Level
Pollock	1969	19R	w-j-r	20	2	37.7	44.0	14	$p < .01$
Pollock	1969		w-j-r	20	4	36.7	49.3	26	$p < .01$
Knuttgen	1970	20	r	10	3	45.8	52.6	16	$p < .001$
Knuttgen	1970	9	r	10	3	43.1	53.4	22	$p < .001$
Knuttgen	1970	8	r	5	5	46.4	57.0	22	$p < .001$
Brynteson*	1973	21R	e	5	1	46.8	45.5	-1	NS
Brynteson*	1973		e	5	2	46.9	46.0	-1	NS
Brynteson*	1973		e	5	3	49.0	48.6	1	NS
Brynteson*	1973		e	5	4	47.9	49.3	1	NS
Wenger	1975	12	e	7	3	39.5	53.3	33	$p < .001$
Wenger	1975	12	e	7	3	39.3	48.9	24	$p < .001$
Milesis	1976	14	w-j	20	3	45.0	48.9	9	$p < .01$
Milesis	1976	17	w-j	20	3	41.5	48.3	16	$p < .01$
Milesis	1976	12	w-j	20	3	45.4	53.1	17	$p < .01$
Hickson	1977	8	r	10	6	38.6	55.4	44	$p < .05$
Dolgener	1978	7	r	6	3	35.5	40.8	11	NS
Dolgener	1978	5	r	6	3	39.3	43.6	9	NS

* maintenance program with frequency reduced from 5 days/week

walk (w), jog (j), run (r), ergometer (e), no significance (NS), randomly divided (R)

equated in terms of physical fitness (Wenger and MacNab, 1975). They examined 36 males with a mean age of 27.9 years, who were volunteers from the Edmonton Fire Department. All the subjects were given pre and post training maximum oxygen consumption tests on the bicycle ergometer. The subjects were ranked according to their $\dot{V}O_2$max values and then divided into four blocks with nine subjects in each block. The nine subjects from each block were then assigned to two training groups and one control group. Therefore, there were 12 subjects in each group consisting of three subjects from each of the four fitness groups. This simple procedure served to equate the three training groups on initial fitness as measured by $\dot{V}O_2$max.

The relationship between the intensity frequency, duration and mode of physical training and the development of aerobic power, has been discussed by many authors (Pollock et al., 1969; Davies and Knibbs, 1971; Brynteson and Sinning, 1973; and Milesis et al., 1976).

Davies and Knibbs (1971) examined the effects of various regimes of bicycle ergometer exercise of varied intensity, duration and frequency of effort on directly measured $\dot{V}O_2$max. The subjects were 28 healthy males aged 18 to 38 years. The subjects were randomly allotted to one of 27 procedures with one subject acting as a control. Each subject was required to work at 80, 50 or 30% of his $\dot{V}O_2$max; for 20, 10 or 5 minutes; five, three or one occasion per week. The subjects were tested maximally and submaximally before and after the training program. Due to the nature of the design, it was impossible to make profound statements about any single combination of intensity frequency and duration. However, it was important to note that there were no changes in aerobic power in any of the subjects who exercised below 50% of their $\dot{V}O_2$max, irrespective of duration and frequency.

Wenger and MacNab (1975) trained their subjects at 100 and 60% of their pre training maximal workload. The pre and post tests consisted of a maximal oxygen consumption test on the bicycle ergometer. In order to equate the intensity of training with the duration of training both groups did exactly the same amount of work per session. Subjects of similar fitness level but in different groups were yoked together. The total amount of work done by one subject in the 100% $\dot{V}O_2$max group was assigned to his matched partner in the 60% $\dot{V}O_2$max group. Over the seven week training program the $\dot{V}O_2$max increased from 39.5 to 53.3 $ml.kg^{-1}.min^{-1}$ in the 100% group and from 39.3 to 48.9 in the 60% group. The control group remained unchanged during this period (40.5 $ml.kg^{-1}.min^{-1}$). It was concluded that the magnitude of the relative intensity was the critical factor in achieving optimal increases in maximum oxygen consumption. If the duration was the critical factor the 60% $\dot{V}O_2$max group should have produced better results. If the total work done was the critical factor then both groups should have been equal.

Milesis et al. (1970) attempted to equate changes in $\dot{V}O_2$max with training programs of 15, 30, and 45 minutes in duration performed three days per week at approximately 85 to 90% of maximal heart rate. The subjects were 19 sedentary inmates, aged 20 to 35 years ($\overline{X}$ = 28.0 years) from a California prison. The conditioning program included running and walking approximately 1.75, 3.25, and 5.1 miles for the 15, 30, and 45 minute groups, respectively. The maximal aerobic power was assessed by a continuous multistage, running treadmill test to voluntary exhaustion. The improvements in the $\dot{V}O_2$max were 8.5, 16.1, and 16.8% which were in proportion to the duration of running. The increase in $\dot{V}O_2$max in each of the 3 experimental groups was significant if compared to the control group. There was also a significant difference between the 45 and 15

minute groups. It was concluded that a program of 15 minutes in duration, three times per week of moderate intensity had considerable merit. However, if time was not a critical factor, a 30 minute program was preferable. A training program of 45 minutes in duration was not recommended for beginners because of the significantly greater percent of injuries.

Nineteen volunteer men, with a mean age of 32.5 years, were randomly assigned to either Group I who exercised two days per week or Group II who exercised 4 days per week (Pollock et al., 1969). The twenty week training program consisted of 30 minutes of walking, jogging, or running. Maximum oxygen uptake was measured directly in response to a treadmill run, at the beginning, middle, and at the end of the program. Group I had an overall increase in $\dot{V}O_2max$ from 37.7 to 44.0 $ml.kg^{-1}.min^{-1}$. Group II had an overall increase from 36.7 to 49.3 $ml.kg^{-1}.min^{-1}$. It was concluded that the four day per week program elicited significantly greater gains in maximal aerobic power as compared to a two day per week program.

Brynteson and Sinning (1973) determined that once a particular level of aerobic fitness is attained, it could be maintained at a lower frequency, if the intensity remained the same. The purpose of their study was to study the effects of training one, two, three, or four times per week, following a training program in which subjects exercised five times per week. The subjects were twenty-one male volunteers who ranged in age from 20 to 28 years ($\overline{X}$ = 28). Each subject trained at a heart rate equal to 80% of his maximum for a duration of 30 minutes. Maximal oxygen uptake was determined by a direct bicycle ergometer test. The improvement in the $\dot{V}O_2max$ over the five week training period was 13% (42.3 to 47.6 $ml.kg^{-1}.min^{-1}$). After an additional five weeks of exercise, it was found that the $\dot{V}O_2max$ values were maintained if the subject exercised for at least three times per week.

When designing a training program to increase maximal aerobic power, it is important to consider the mode of exercise. Since the highest level of $\dot{V}O_2$max is attained during exercise with large muscle masses, it seems logical that a subject train in this capacity (Clausen, 1977). Substantial increments in maximal aerobic power has been observed as a result of jogging or running (Wilmore et al., 1980; and Hickson et al., 1977).

Wilmore et al. (1980) examined the physiological alterations consequent to a 20 week program of bicycling, tennis, and jogging. The subjects were 38 male employees of the City of Davis and University of California, Davis Police and Fire Departments. Nine subjects were randomly assigned to each of three programs and one control group. The experimental groups exercised for 30 minutes per day, three days per week. Subjects in the jogging and bicycling groups performed maximal tests on the treadmill and the cycle ergometer. There were significant increases in $\dot{V}O_2$max for the jogging group (42.2 to 47.8 ml.kg^{-1}.min^{-1}) and in the cycling group (38.6 to 44.3 ml.kg^{-1}.min^{-1}). Since there was no specificity of training effect between the jogging and cycling modes, it was concluded that both were comparable in the development of cardiovascular fitness.

Hickson et al. (1977) postulated that if the training stimulus was kept constant relative to maximal aerobic capacity, endurance and aerobic power would increase linearly initially and then start to level off as the individual's $\dot{V}O_2$max began to approach its genetically determined upper limit. Eight healthy but sedentary subjects, aged 20 to 42 years, exercised six days per week for 10 weeks. The training program consisted of running three days per week and bicycling on an ergometer on alternate days. The running program consisted of continuous running, as fast as possible for 30 minutes per day the first week, 35 minutes per day the

second week, and 40 minutes or more for the subsequent weeks. The ergometer program consisted of six, 5 minute intervals of pedalling against a resistance strong enough to elicit $\dot{V}O_2$max. Each five minute bout was separated by a two minute recovery period during which the subject exercised at 50 to 60% $\dot{V}O_2$max. The maximum oxygen uptake as measured directly on the bicycle ergometer, increased linearly with the training stimulus throughout the entire 10 week period. The magnitude of the increase was from 38.6 to 56.4 $ml.kg^{-1}.min^{-1}$, an increase of 44%.

Dolgener and Brooks (1978) observed the effects of interval training on $\dot{V}O_2$max and performance in the mile run. The subjects were 14 male volunteers enrolled at the University of Cincinnati. The subjects were randomly divided into a continuous group (CG) and an internal group (IG). The training sessions were conducted 50 minutes per day, three times per week. The CG trained one mile the first day, one-and-a-quarter miles the second day, and one-and-a-half miles thereafter. The running intensity was individually adjusted to elicit 80% of maximum heart rate. The IG ran intervals of 220 yards at maximal speeds with a 220 yard walk between each interval. The subjects ran 220 yards the first day, ten times 220 yards the second day, and twelve times 220 yards thereafter. Maximum oxygen uptake on the bicycle ergometer and performance in a mile run were tested before and after the six week period. The maximum oxygen uptake increased from 35.5 to 40.8 $ml.kg^{-1}.min^{-1}$ and from 39.3 to 43.6 $ml.kg^{-1}.min^{-1}$ in IG and CG respectively. The CG had an almost identical improvement in $\dot{V}O_2$max as compared to the IG, however because two subjects dropped out of CG, the improvement was not significant. It was concluded that there was no clear superiority of either interval training or continuous distance running in improving $\dot{V}O_2$max or decreasing the time in the mile run.

The purpose of a study by Knuttgen et al. (1973) was to evaluate different forms of intense interval training upon certain physiological performance capacities of young male subjects. The subjects, military conscripts from the First Swedish Communications Regiment, were divided into three training groups (see Table 2.2). Group I and Group II trained for a period of two months while Group III did not begin training until after the first month. All groups were tested on three occasions. Test 1, at the beginning; Test 2, after the first month; and Test 3, at the end of the program. The assessment of $\dot{V}O_2max$ was done submaximally and maximally on a electronically braked bicycle ergometer. Maximum oxygen uptake significantly increased in all 3 groups from Test 1 to Test 2 ($p < .01$) and from Test 1 to Test 3 ($p < .001$). There was a significant difference from Test 2 to Test 3 in Groups I and III ($p < .001$) but not for Group II ($p < .05$). It was concluded that the concept of all-out

TABLE 2.2

INTERVAL CONDITIONING PROGRAM*

Group	N	$\bar{X}$ Age	Intensity	Duration	Frequency
I	20	20.6	15 sec exercise 15 sec rest	15 min/session	1 session/day 3 x/week
II	9	20.2	3 min exercise 3 min rest	15 min/session	1 session/day 3 x/week
III	8	20.6	15 sec exercise 15 sec rest	15 min/session	1 session/day 5 x/week

*Knuttgen et al. (1973)

exercise for short intervals, with appropriate rest periods was a viable method to bring about a large increase in the transport and the utilization of oxygen in a short period of time. The most impressive results occurred in the subjects who trained for 3 minutes with a 3 minute rest interval.

Adaptations with Detraining

From the previous review of various training studies, it was observed that the human body has a tremendous ability to physiologically adapt to a structured program of exercise. Unfortunately once the stimulus is removed, the body has a tendency to revert back to its original status.

Along with quantifying the physical adaptations to training, the measurement of $\dot{V}O_2max$ appears to be the only way to quantify, in functional terms, adaptations to inactivity (Saltin and Rowell, 1980).

Miyashita et al. (1978) evaluated the physiological effects of both physical training and detraining on maximal aerobic power. The subjects were eleven Japanese sedentary men aged 35 to 54 years. The training involved walking for 10 minutes on a treadmill at a constant speed of 110 meters per minute and at a sufficient grade to elicit 80% of $\dot{V}O_2max$. The training program was performed three days per week for a total of 15 weeks. Maximal aerobic power, measured via a maximal treadmill test, significantly increased from 36.9 to 41.3 $ml.kg^{-1}.min^{-1}$, an average increase of 12% ($p < .001$). After six months of detraining the $\dot{V}O_2max$ value regressed to 38.3 $ml.kg^{-1}.min^{-1}$, a decrease of 7% ($p < .001$). A significant correlation ($r = .952$) was also found between the percent increase in $\dot{V}O_2max$ and the percent increase in maximal cardiac output. Conversely, there was a correlation ($r = .855$) between both parameters as a result of detraining. The mean gain in maximal aerobic power had not disappeared

completely even after six months of physical detraining.

Knuttgen et al. (1973) were able to test a certain number of their subjects from the original groups, a fourth time, eight months after the cessation of training. It was discovered that the fitness level of each subgroup decreased significantly and returned to levels not different from initial values.

Cardiovascular changes were measured to determine changes in physical fitness attributable to equal eight work periods of training, non-training, and re-training (Cureton and Phillips, 1964). Six volunteer males and four controls age 28 to 47, were the subjects for this experiment. The training program consisted of approximately fifteen minutes of calisthenics, followed by 30 to 50 minutes of cross country running and finally 30 minutes of handball or squash. Absolute changes in fitness levels were difficult to ascertain because the raw scores were only represented graphically. However, it was evident that the experimental group had a greater increase in fitness as opposed to the control group as a result of the initial eight weeks of training. During the eight week period of non-training the experimental group decreased in fitness but not back to initial levels. A final eight weeks of more intense exercise elicited the highest level of physical fitness, in terms of gross maximal oxygen uptake.

Influence of Warm-up Exercise on Cardiovascular Function

The adverse effects of sudden strenuous exercise on the cardiovascular system has been reviewed previously (Barnard et al., 1973). Research on the effects of warm-up exercises has found that they may have some positive influences on the cardiovascular response (Inger and Stromme, 1979; Martin et al., 1975; and Anzel, 1978).

Inger and Stromme (1978) investigated the effects of active, passive

or no warm-up on the physiological response to a maximum aerobic workload. The active warm-up was a run on a treadmill at a submaximal workload of 50 to 60% of $\dot{V}O_2$max. The passive warm-up consisted of sitting immersed in water to the neck at a temperature of 40°C. The criterion task consisted of running uphill, at a 3% grade for four minutes, at speed requiring 100% $\dot{V}O_2$max. There was a significant increase in $\dot{V}O_2$max after an active warm-up as compared to a passive warm-up or no warm-up ($p < .05$). The authors concluded that the results strongly emphasized the beneficial effects of an active warm-up on athletic performance.

The separation of the relative contributions of physiological and psychological influence of warm-ups on $\dot{V}O_2$max has been attempted by Martin et al. (1975). A ninety second treadmill run at 23.6 km/hour up to a 2% grade was used as a criterion run. All the runs were preceeded by either 30 minutes of rest or by either of two warm-ups. The first warm-up was a 15 minute run, at 10 km/hour, at a 2% grade. The second warm-up was similar to the first but differentiated by an inclusion of a three minute period of rest before the criterion run. The authors concluded that for $\dot{V}O_2$max to be measured effectively an adequate period of warm-up was necessary. Since there were only two subjects in this study their conclusion was quite speculative.

Andzel (1978) examined the effects of prior exercise and varied rest intervals on cardiorespiratory endurance performance with no prior warm-up. The prior exercise was a two minute treadmill run designed to raise the heart rate to approximately 140 bpm. The subjects then rested for 30, 60, 90, and 120 seconds before encountering an all-out treadmill run to exhaustion. The best performance was after a prior warm-up exercise with a 30 second rest before the criterion run. The explanation for this result was that too long a rest period caused a decrease in the oxygen

mobilization process, after the initial warm-up increase.

The effects of warm-up on cardiovascular response may be different in trained as opposed to untrained individuals (Knowlton et al., 1978). Seven untrained male subjects were studied to observe the effects of mild warm-up exercise on oxygen consumption. There were no differences for the measured physiological variables between tests that had prior warm-up activity or tests that had no prior warm-up activity ($p < .05$).

Other investigators have also failed to register significant gains in cardiovascular performance as a result of warm-up exercise (Busuttil and Ruhling, 1977; and De Bruyn-Prevost, 1980). However, the authors did not rule out the possible positive effects of warm-ups in the prevention of injury or reduced muscle soreness.

EFFECTS OF ENDURANCE TRAINING ON BODY COMPOSITION

Since maximal aerobic power is a function of body weight, body composition is an important factor to consider in terms of physical fitness. For most purposes, body composition is divided into two fractions: lean mass and fat mass (Fox, 1979). An increase in lean mass as a result of endurance training generally has a positive effect on $\dot{V}O_2$max whereas an increase in percent body fat has an adverse effect. A large amount of fat is detrimental to performance in two ways: it costs energy to move the fat, and the excess fat does not contribute toward the energy production (Fox and Mathews, 1976). The appropriate amount of fat for Canadian males, ages 20 to 29 years is 13 to 17%. However, the average amount of fat for this age group is generally in the range of 18 to 22% (Canadian Public Health Association, 1978).

Prediction of Percent Body Fat

Some of the techniques for predicting percent body fat are: hydrostatic weighing, skinfolds, potassium-k-40, radiography, and ultrasound techniques (Behnke and Wilmore, 1974). The purpose of this section is to offer some rationale for using the skinfold technique to estimate percent body fat and to outline some of the assumptions and principles involved in this method.

The problem with height-weight charts for determining optimum weight is their failure to consider the relative components of lean and fat mass. A highly trained professional football player is often considered to be overweight by this standard, although having a low percent of body fat (Adams et al., 1982). Conversely, a slim person may meet the weight standard for a particular height but have a large percent of fat mass due to a concomitant low percent of lean mass. A better way to classify an individual's body composition status would be to use the term overfat as opposed to overweight. The prediction of fat using the skinfold technique attempts to redefine this status.

A skinfold, measured by fat calipers, contains a double layer of skin and subcutaneous fat (Fletcher, 1961). Careful application of the calipers must be made so that no underlying muscle is included (Brozek and Keys, 1951). The use of this procedure depends on the assumption that the subcutaneous fat constitutes a constant or at least a predictable proportion of the total body fat (Womersley and Durnin, 1977). Therefore a change in percent body fat is signified by a change in subcutaneous fat measured in millimeters.

Most predictive equations or skinfold charts are based on the relationship between skinfold thickness and body density (Brozek and Keys, 1951; Durnin and Rahaman, 1967; and Durnin and Womersley, 1973). Durnin and

Rahaman (1967) found that this relationship was sufficiently uniform so that regression equations and tables could be constructed to calculate percent body fat on this basis in adolescents and young adults. The correlation coefficients for total skinfold thickness and body density were -.835 and -.778 in the young men and women respectively (n = 105 males and 86 females). A follow-up study on a more diverse population produced coefficients that ranged from -.7 to -.9 for the different age groups in both men and women (Durnin and Womersley, 1974). The general conclusion from both reports was that the skinfold technique could assess percent body fat with relative ease and reasonable accuracy.

Body Composition Changes as a Result of Physical Training

Vogel et al. (1978) examined the relationship between aerobic fitness and body fat during army recruit training. Two hundred and fifty-four soldiers were tested at the beginning and the end of a three month training program. Body weight increased slightly but not significantly. However, body fat decreased by 8.6% and lean body mass increased by an average of 1.1 kilograms, both changes were significant ($p < 0.001$). Body fat was estimated from the bicep, tricep, suprailiac, and subscapula skinfold sites. The fact that percent body fat decreased whereas total body weight remained the same, reinforces the value of this measurement. Obviously, for the weight to remain the same there must have been fat catabolism with concomitant protein anabolism.

Wilmore et al. (1970) evaluated body composition changes in 55 men between the ages of 17 to 59 years after a three day per week, 20 week program. The purpose of the study was to investigate whether an exercise program of jogging was of sufficient intensity to induce significant changes in body composition. Skinfold measurements were taken on

right side of the body using the Lange skinfold caliber. The selected sites for this study were: scapula, triceps, chest, midaxillary, supra-iliac, abdomen and thigh. Small but significant reductions in body composition was observed ($p < .05$). The percent body fat dropped from 18.9 to 17.8%.

An attempt was made to quantify the effects of 15, 30, and 45 minutes of conditioning on maximal performance, cardiovascular fitness variables, and body composition (Milesis et al., 1976). The methods and procedures have been reviewed earlier. The anthropometric assessment included body weight, height, and skinfold fat measurements at the chest, triceps, abdomen, suprailiac, and front thigh. The effectivensss of the training programs in altering body composition was not anticipated due to initial lean condition of the subjects. However, there were significant decreases in percent fat in the 30 and 45 minute groups (14.2 to 13.6% and 13.2 to 12.0% respectively).

Pollock et al. (1969) observed the effects of frequency of training on working capacity, cardiovascular function and body composition of adult men. Body composition measurements included the sum of skinfolds obtained over the chest, axilla, triceps, abdomen, suprailiac, and front thigh. There were two experimental groups in this study. Group I who exercised 2 days per week and Group II who exercised 4 days per week, for a total of 20 weeks. Group II showed a reduction in skinfolds from Test 1 to Test 3 of 19.6 to 18.6%. It was concluded that a four day per week program elicited a more significant improvement in body composition than two days per week.

EFFECTS OF CIRCUIT TRAINING ON CARDIOVASCULAR, STRENGTH, AND BODY COMPOSITION CHANGES

Although circuit training appears to be an effective training technique for altering muscular strength and endurance, its effect on cardiorespiratory endurance is limited (Fox, 1979). The little research that has been done on circuit training seems to focus mostly on muscular strength and endurance.

Gettman et al. (1978) examined the effect of circuit weight training on strength, cardiorespiratory function, and body composition of adult men. The subjects were 70 volunteer male police officers, aged 21 to 35 years. Maximum oxygen uptake was assessed before and after the training program by a maximal treadmill test. Body compositions were determined by the body density and skinfolds. Cybex isokinetic test apparatus was used to assess muscular strength. After the initial testing was completed, the subjects were randomly assigned to one of three groups: a circuit weight training group (CWT, n = 20), a continuous running group (CR, n = 30), and a sedentary control group (C, n = 20). A standard warm-up period that involved various stretching and calisthenic exercises and cycling for two minutes at 900 kilograms per meter per minute was performed in the first 15 minutes of the workout. The CWT program was constructed so that each subject worked at 50% of their one repetition maximum strength on Universal Gymn apparatus. After an initial period of adjustment, 15 repetitions per set were used as the standard for the remainder of the 20 week program. The subjects moved continuously from station to station with a 30, 25, and finally a 20 second rest period between stages. The total circuit consisted of 10 exercises that were repeated twice in the following sequence: bench press, knee extension, hamstring circle, biceps curl, dips, leg press, sit-ups, shoulder press,

lat pull, and upright rowing. The CWT was quantified by total workout time, total work and weight resistance relative to maximum strength, and heart rate intensity.

The endurance program consisted of a combination of walking and jogging equal distances at first, with gradual increases in jogging made throughout the program. The final few weeks consisted of continuous jogging for 30 minutes. The distances and the times of each jogging and walking segments were recorded each workout to quantify the training of the running program. The intensity of the CR was regulated at 85% of maximum heart rate.

The strength gains were higher in the CWT group as compared to the RN group but the difference was not significant. The increase in $\dot{V}O_2max$ was significantly higher in the CR group than the CWT group, 41.3 to 47.6 ml/kg/min and 40.0 to 41.4 ml/kg/min respectively. The CR group increased 1.7 kilograms in lean body weight compared to an increase of 1.0 kg in the CWT group. In addition, the CR group lost more fat weight (-2.2 kg) than the CWT group (-1.3 kg). The authors concluded that the circuit weight training program was most specific in improving muscular strength and produced only a small aerobic effect as measured by the treadmill running test.

The ability of a 10 week circuit weight training program to elicit specific physiological alterations was evaluated by Wilmore et al. (1978). Twenty-four women and 26 men were randomly assigned either to a circult weight training program or a control group. Body composition was assessed by the underwater weighing technique and by skinfold measurement. Strength was assessed using one repetition maximum technique and the Cybex. Maximum oxygen uptake was measured via a treadmill walk-run to exhaustion. The training program consisted of three 7 to 5 minute circuits per day with three sessions per week. All exercises were performed on a Universal Gym

in the following order: bench press, inclined sit-ups, leg press, lat pull, back arch, shoulder press, leg extension, arm curl, leg flexion, and upright rowing. All the subjects exercised at 40 to 55% of their maximal strength and executed as many repetitions as possible in 30 seconds. There was a 30 second rest period between exercises to allow the subjects time to move to the next station.

There was a significant increase in lean body weight for both men and women and a significant decrease in percent fat for the women (28.1 to 26.3%). The women also had a significant increase in $\dot{V}O_2$max from 35.5 to 39.3 $ml.kg^{-1}.min^{-1}$. The only significant improvement for the men was in strength gains. The authors explained the small insignificant decrease in fat weight by the fact that the control group changed slightly and the duration of 10 weeks may have been too short. However, they still concluded that circuit weight training appeared to be an effective method to alter body compositions, increase strength, and increase endurance time to exhaustion.

FIRE FIGHTER TRAINING PROGRAMS

In an attempt to reduce the incidence of cardiovascular disease and the number of job related injuries in fire fighting, some Fire Departments have initiated physical training programs for regular staff as well as trainees.

The Los Angeles City Fire Department instituted a mandatory physical fitness program in 1971 for all its 3,250 members (Barnard and Anthony, 1980). Each member had to meet the following medical criteria to enter the program: have received a medical examination within the preceeding year, be not more than 20% over the maximum recommended weight, have blood pressure not in excess of 150/85, not be on a restricted or

rehabilitative status abide by medical restrictions set forth in a medical report, and not be under treatment or observation for cardiac abnormalities. Only seven fire fighters did not meet this criteria.

The program was conducted early in the morning, the time at which the men were least busy. It was 45 minutes in duration and consisted of flexibility and warm-up exercises, cardiovascular exercises, muscle conditioning exercises, and a cool down period. The program was generally conducted in the fire station but occasionally at school facilities if they were in visual contact with the station. To evaluate the effectiveness of the program, a random sample of 300 periodic medical examinations were studied to determine if there were any changes in cholesterol, blood pressure, and body weight. A Kasch Fitness Index was used to determine the changes in fitness level.

In 1971, 38.6% of the fire fighters had fitness score values in the poor and very poor categories. This percentage dropped to 12.7 and 9.0% in 1975 and 1978 respectively. The health maintenance programs had no significant effects on blood pressure, but there was a significant reduction in blood cholesterol levels.

In conclusion, the Los Angeles Fire Department's health maintenance program was beneficial in increasing fitness levels and reducing some risk factor associated with atherosclerotic heat disease. It was also concluded that the physiological adaptations appeared to reduce the number of on the job fire fighter injuries. Mealey (1979) reported that between 1971 and 1972 the department logged 2,134 on-duty injuries, but between 1977 and 1978 that number dropped to 1,814. The total number of members in the department remained the same.

The incorporation of a fitness program into a Fire Department takes the right combination of support from the top and an adequate amount of

funding to make it a reality (Beam, 1979). Chief Charles H. Rule of the Alexandria Fire Department designed a committee diverse in expertise and professional interests in order to accomplish this objective. The committee representatives were: a Fire Captain, Battalion Chief, Personnel Analyst, Affirmation Action Officer, and a Union Representative. The committee's responsibility was to examine the feasibility of a fitness program from many perspectives, thus arresting problems that might have occurred during implementation.

Probably the most difficult task in establishing the program was to convince the City Council that the program should be funded. Their rationale was based on the potential savings that could be derived from having healthier fire fighters. Earlier evidence of reduced sick leave in a fitness group supported their claim. A study in the Alexandria Fire Department found a 17% decrease in sick leave in a physical fitness group over a two year period (1974 to 1976).

The program's objectives were as follows:

> To improve every employee's physical fitness, thus reducing the annual number of on-the-job accidents and injuries.
>
> To campaign against smoking and reduce, by 30% the number of persons in the fire department who smoke.
>
> To ensure that all uniformed fire and emergency medical services personnel participate in the physical fitness program and achieve their prescribed personal fitness goals (p. 16).

The participants were required to spend one hour each day, three days per week on physical fitness activities. The program consisted of 10 minutes of flexibility and warm-up exercises, 20 minutes on strength exercises, and 30 minutes on cardiovascular endurance. All of the eight Alexandria fire stations were equipped with a set of weights, bench, stationary cycle, jump rope, exercise mat, and a doorway chip-up bar.

After the first year of the mandatory program, each participant was tested for improved fitness (see Table 2.3). Since two different modalities were used to assess the cardiovascular changes, an accurate comparison could not be made. The body composition changes indicated an increase in lean body mass and a decrease in percent body fat. The skinfold measurements or percent body fat dropped from 23.8 to 18.0%. This value represented an 11 pound reduction in fat weight per person. Collectively, all the participants in the program lost close to one ton of fat. The increase in lean body mass corresponded to the general increase of all the neuromuscular parameters.

The preliminary evidence indicated that the Alexandria Fire Department personnel were beginning to attain positive physical changes as a result of their fitness program. There was optimism that these payoffs would lead to future reduction in costs of early disability pension, loss of time due to accidents, less use of disability leave and most importantly, a healthier and more efficient fire department.

Due to the tremendous cost to the county and city agencies a preliminary physical training program was implemented to reduce the drop-out rate of recruits during the tower training drills (Pipes, 1977). The purpose of this study was to investigate the effectiveness of interval running and circuit weight training as a means of increasing the physical work capacity of fire fighter recruits. The subjects of this study were 27 male recruits from the Los Angeles City Fire Department aged 21 to 29 years. The interval training consisted of two minutes of running and one minute of walking for a total duration of 18 minutes, which progressed to 45 minutes at the end of the program. All the subjects performed the circuit weight training 10 minutes after the interval running. The stations included: bench press, military press, leg press, sit-ups, leg

TABLE 2.3

ALEXANDRIA FIRE DEPARTMENT: FITNESS PARAMETERS

Parameters	1977 $\overline{X}$	1977 SD	1978 $\overline{X}$	1978 SD	Change	% Change
Sit-ups	24.4	11.4	33.4	12.7	+ 9.2*	+38.0
Push-ups	16.4	8.8	19.4	10.0	+ 3.0**	+13.0
Long jump	74.4	10.5	77.8	11.4	+ 3.4**	+ 4.5
Chin-ups	3.0	2.7	4.7	3.4	+ 1.7	+56.6
Grip strength R	52.9	9.9	51.3	14.2	- 1.6**	- 5.7
(kg) L	52.4	9.0	47.8	13.8	- 4.6*	
Flexibility (inches)	- .9	4.4	+ 2.9	3.9	+ 3.8*	+31.6
5 rep. max: bench	105.9	22.6	117.0	30.5	+11.1*	+10.0
military	91.9	17.4	101.2	21.5	+ 9.3*	+10.0
curls	61.4	9.5	61.4	14.7	-	-
Weight (kg)	82.5	12.0	81.2	11.8	- 1.3*	- 1.6
Percent body fat	23.8	10.0	18.0	8.4	- 5.8*	-24.0
$\dot{V}O_2max$ ($ml.kg^{-1}.min^{-1}$	39.9	9.6	36.2	10.4	- 1.7**	- 4.5
	(bike)		(treadmill)			

Bean (1979)

n = 147
* = significant at .01
** = significant at .05

lifts, biceps curl, pull downs, back arch, dead lift, and rope climb. The subjects exercised at 50% of their one repetition maximum for 30 seconds, with a 15 second rest between station. All participants completed three, 8 minute circuits. Including a 15 minute warm-up and cool down period, the total program lasted 90 minutes.

All of the subjects were given a battery of tests before and after the 10 week training period. The tests included a work capacity test on the bicycle ergometer, six physical performance tests, dynamic muscular strength tests, and an estimate of percent body fat using skinfolds.

There were significant increases in the performance tests and the dynamic strength tests ($p < .05$). Although there was not a significant change in body weight, the lean body weight increased significantly (26%) and the absolute and relative body fat decreased significantly (-13.4 and -13.7% respectively).

The improved physical capacity of the recruits appeared to be an effective means to increase their performance in the departmental rigors of the tower drills and to decrease their drop-out cost.

The nature of the fire fighting task imposes a substantial amount of cardiovascular stress on the human body. It is imperative that steps be taken to adequately prepare fire fighters to meet the rigors of their occupation.

CHAPTER III

METHODOLOGY

SUBJECTS

The subjects were 56 male fire fighter recruits between the ages of 21 and 29 ($\overline{X}$ = 23.5, SD = 2.1) years. The subjects were from two separate recruit training classes. Class 83 (Group A, n = 24) commenced training October 19, 1981 and class 84 (Group B, n = 32), February 18, 1982. The training programs were approximately nine weeks in duration.

EXPERIMENTAL DESIGN

Three testing sessions were used to collect the data. Test one was administered before the nine week training program, test two immediately following the program, and test three, approximately nine weeks after a period of detraining. The test parameters were divided into three sections: functional-performance tests, body composition assessment, and a knowledge test. Group A and Group B were not equally involved in all the test sections (see Table 3.1). Both groups were equated on the basis that every subject was required to be above the 70th percentile on their combined functional-performance test scores to qualify for the recruit training program. The percentile rank was in comparison to all the applicant scores from past fire fighter testing (approximately 2,500 men).

PROCEDURE

Functional-Performance Tests

The functional-performance tests were designed by the faculty of

TABLE 3.1

EXPERIMENTAL DESIGN

Test Parameters	T_1 before 9 wks. tr.	T_2 after 9 wks. tr.	T_3 after 9 wks. detr.
functional-performance tests	Group A Group B	Group A	Group A
body composition assessment	Group B	Group A Group B	Group A
knowledge test	Group B	Group B	Group A

Physical Education, University of Alberta, to screen potential fire fighter recruits. The tests focused on the physical requirements that were believed to be necessary to effectively accomplish the fire fighter's task.

Upon arrival, the subjects were first registered and weighed. Then the subjects systematically went through the following function-performance test battery:

1. predicted two stage bicycle ergometer $\dot{V}O_2max$ test (Astrand and Ryhming nomogram, 1954)
2. total dips
3. total chin-ups
4. standing long jump
5. stair run
6. agility shuttle run

These tests are described in Appendix A.

Body Composition Assessment

The skinfold technique was used to estimate percent body fat. The Harpenden caliper was employed to measure the skinfold thickness. The

skinfold sites included: the triceps, biceps, suprailiac, and subscapular sites. The standardization procedure is described in Appendix B.

Knowledge Test

A questionnaire was formulated to ascertain the changes in knowledge or awareness during the equal nine week periods of training and detraining. Nineteen multiple choice questions were obtained from qualified personnel who lectured on topics related to the fire fighter occupation. The qualified people and their respective topics were:

Dr. A. Quinney: components of fitness and principles of training

Dr. A. Bolle: stress management

K. Hipkin: psychological damage, smoke, and heat

B. Hanson: nutrition and weight control.

The knowledge questionnaire is presented in Appendix C.

TRAINING PROGRAM*

The subjects trained approximately 50 minutes per day, five days per week, for approximately nine weeks. The physical training program included: warm-up and flexibility exercises, muscular strength and endurance circuits, an aerobic component (running), and cool-down exercises. Criterion mile runs were held at the end of the third, sixth, and ninth weeks. Group B also had a pre-program mile run. A description of the training program is presented in Appendix D.

STATISTICAL ANALYSIS

A one-way analysis of variance with repeated measures (xder: program par = anov 14) was used to determine the significance of differences

*The program was modified slightly between the class 83 training session and the class 84 training session.

between the means for the following dependent variables: $\dot{V}O_2$max, dips, standing long jump, stair run, and the agility shuttle run. The Newman-Keuls post hoc comparison of means test was used if a significant F ratio was obtained.

A correlated t-test was used to determine the significance of difference between the means for the following variables: weight, percent body fat, and the knowledge questionnaire. An independent t-test was used as a test for significance between the questionnaire means for Group A and Group B.

Means and standard deviations were used to compare the differences in the mile times for the criterion run.

Finally, an additional paired t-test was used to determine if the attrition of 12 subjects biased the sample.

An alpha level of p was less than .05, where p was the probability that no difference exists between the means, was established prior to the analysis.

CHAPTER IV

RESULTS AND DISCUSSION

The results and discussion are presented in three sections: functional-performance changes, body composition changes, and knowledge changes. The more important components as they relate to the purpose of this study are integrated in a general discussion at the end of the chapter.

All data reported in this section are in terms of mean data. Tables of raw data are located in Appendix F. The statistical level of significance was established previously ($p < .05$). The subjects were tested on three separate occasions: before the training program, after nine weeks of training, and after a nine week period of detraining.

The discussion of the results is mainly directed towards the nine week training program with the emphasis on the aerobic endurance component ($\dot{V}O_2max$).

FUNCTION-PERFORMANCE CHANGES

The subjects were delimited to the fire fighters who returned for the final test. An independent t-test comparing the means of the initial subjects ($n = 36$) and the sample of test subjects ($n = 24$) showed no significant difference, indicating that the test subjects were a representative sample of the total group. Table 4.1 represents a summary of the functional-performance results.

Predicted $\dot{V}O_2max$

A significant increase in $\dot{V}O_2max$ from 49.0 to 57.6 $ml.kg^{-1}.min^{-1}$ (15%) was observed over the nine week training period (Figure 4.1). Similar

TABLE 4.1

FUNCTIONAL-PERFORMANCE CHANGES

Functional-performance tests	Pre-Training T_1 $\bar{X}$	SD	Post-Training T_2 $\bar{X}$	SD	Post-Detraining T_3 $\bar{X}$	SD	Significance $p < .05$
$\dot{V}O_2max$ ($ml.kg^{-1}.min^{-1}$)	49.0	7.1	57.6	8.2	56.8	7.6	T_1 to T_2 T_1 to T_3
total dips (rep)	17.0	4.4	19.6	7.1	19.0	8.0	
total chin-ups (rep)	12.1	2.5	11.4	3.1	11.7	2.6	
standing long jump (in)	96.0	5.4	92.6	6.7	94.6	4.4	T_1 to T_2 T_2 to T_3
stair run (sec)	3.27	0.20	3.29	0.12	3.27	0.19	
agility shuttle run	12.0	0.9	11.2	0.5	11.9	1.7	T_1 to T_2 T_2 to T_3

increases have been found by Knuttgen (1970) and Milesis (1976), who both found increases of 16% in $\dot{V}O_2max$ in their subjects.

The results are predicted $\dot{V}O_2max$ values with their inherent error of $\pm 6\%$ as compared to the direct $\dot{V}O_2max$ scores (Astrand and Ryhming, 1954; and Keren et al., 1980).

Hickson (1977) reported the largest increase in $\dot{V}O_2max$ from 38.6 to 55.4 $ml.kg^{-1}.min^{-1}$, an increase of 44%. The subjects in this study were healthy but sedentary before the initiation of the 10 week program. The program included high intensity running alternated with bicycle ergometer training six days per week, for a duration of approximately 40 minutes

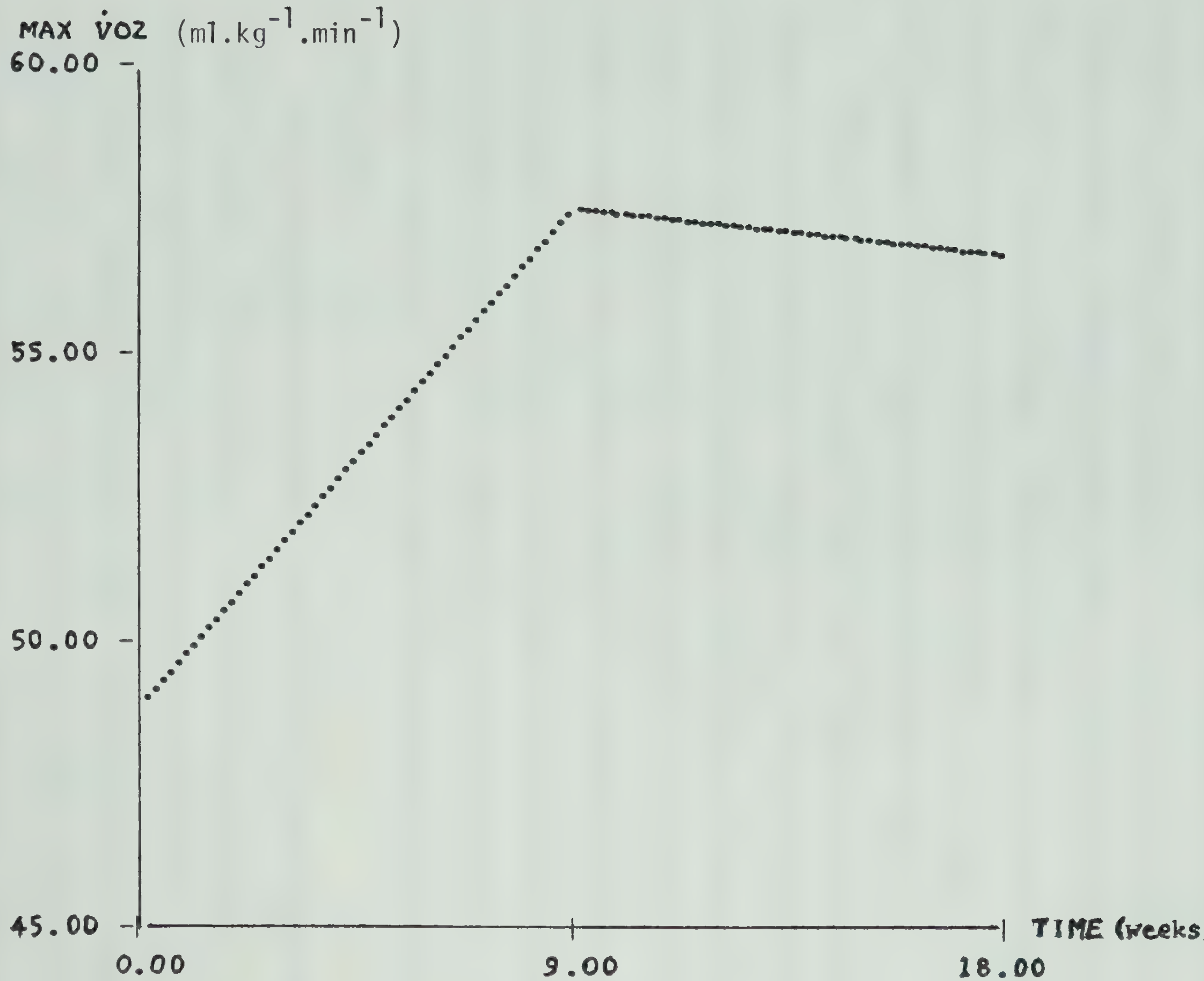

Figure 4.1. Predicted $\dot{V}O_2max$ Changes

per day.

The evaluation of the effectiveness of a training program in terms of increases in $\dot{V}O_2max$ may introduce spurious conclusions. Wenger and MacNab (1975) emphasized the importance of equating initial fitness when comparing different training programs. Sharkey (1970) found that the previous level of fitness yielded a highly significant negative correlation with changes in $\dot{V}O_2max$. The initial level of fitness of the present subjects was high in comparison to the other studies observed. Therefore, the increase of 15% in $\dot{V}O_2max$ appeared to be substantial.

Frequency, duration, and intensity are important considerations in designing a training program (Pollock et al., 1969; and Brynteson and Sinning, 1973). Although the intensity was not monitored in the present study, it appeared that the intensity, duration, and frequency of the fitness program in the present study was of sufficient magnitude to elicit cardiovascular adaptations. The heart rate was occasionally monitored but this did not lead to an adjustment in training intensity. The subjects trained five times per week, 30 minutes per session for a total of nine weeks.

The cardiovascular component of the training program emphasized aerobic running. The subjects ran from one to three miles per day, averaging approximately 1.5 miles per day for the duration of the training program. A one mile criterion run was performed at the beginning (Group A), and at the third, sixth, and ninth week of training (Group A and Group B). These results can be seen in Figure 4.2. Noticeable decreases in the mile times were observed in both Group B (5:59 to 5:31 min:sec) and in Group A (6:01 to 5:40 min:sec). Dolgener (1978) also found a decrease in mile times after a six week running program from 6:22 to 5:55 min:sec.

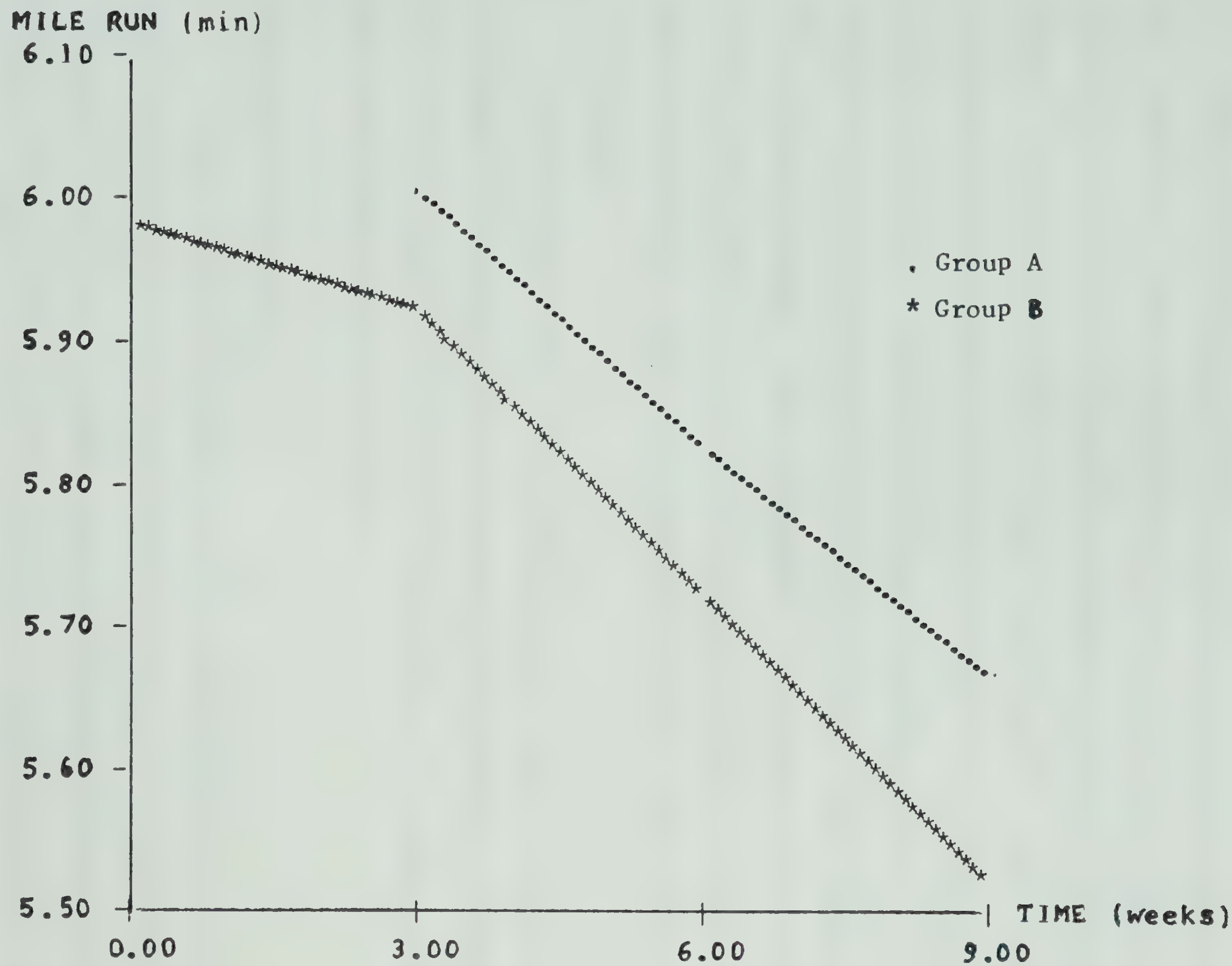

Figure 4.2. Criterion Run Times for Group A and B

There was no significant difference in the predicted $\dot{V}O_2max$ scores after a nine week period of detraining (see Figure 4.1). The values decreased slightly from 57.6 to 56.8 $ml.kg^{-1}.min^{-1}$.

Brynteson and Sinning (1973) studied the effects of training one, two, three, and four times per week on the retention of $\dot{V}O_2max$. The subjects were initially trained five times per week for a period of five weeks. The average increase in $\dot{V}O_2max$ was from 42.3 to 47.6 $ml.kg^{-1}.min^{-1}$. The group of subjects who trained once a week for an additional five weeks demonstrated a decrease in $\dot{V}O_2max$ from 46.8 to 45.5 $ml.kg^{-1}.min^{-1}$, which was similar to the decrease observed in the present study. This evidence suggests that the subjects in the present study would have had to train aerobically at least once a week during the detraining period to prevent a significant decrease in their cardiovascular fitness as observed.

The remaining functional-performance test results are performance indicators of various physical parameters. The detraining changes are discussed as a whole at the end of this section. The means and standard deviations are presented in Table 4.1.

Total Dips and Chin-ups

No significant changes were found for total number of dips or chin-ups at the end of the nine week training program. The total dips increased from 17 to 19.6 repetitions (see Figure 4.3), whereas the total number of chin-ups decreased from 12.1 to 11.4 repetitions (see Figure 4.4). The muscular strength and endurance circuit of the training program included exercises that were similar to the dip test. These exercises also stressed the triceps muscle group which may have accounted for the slight increase in dips. Conversely, the training program did not

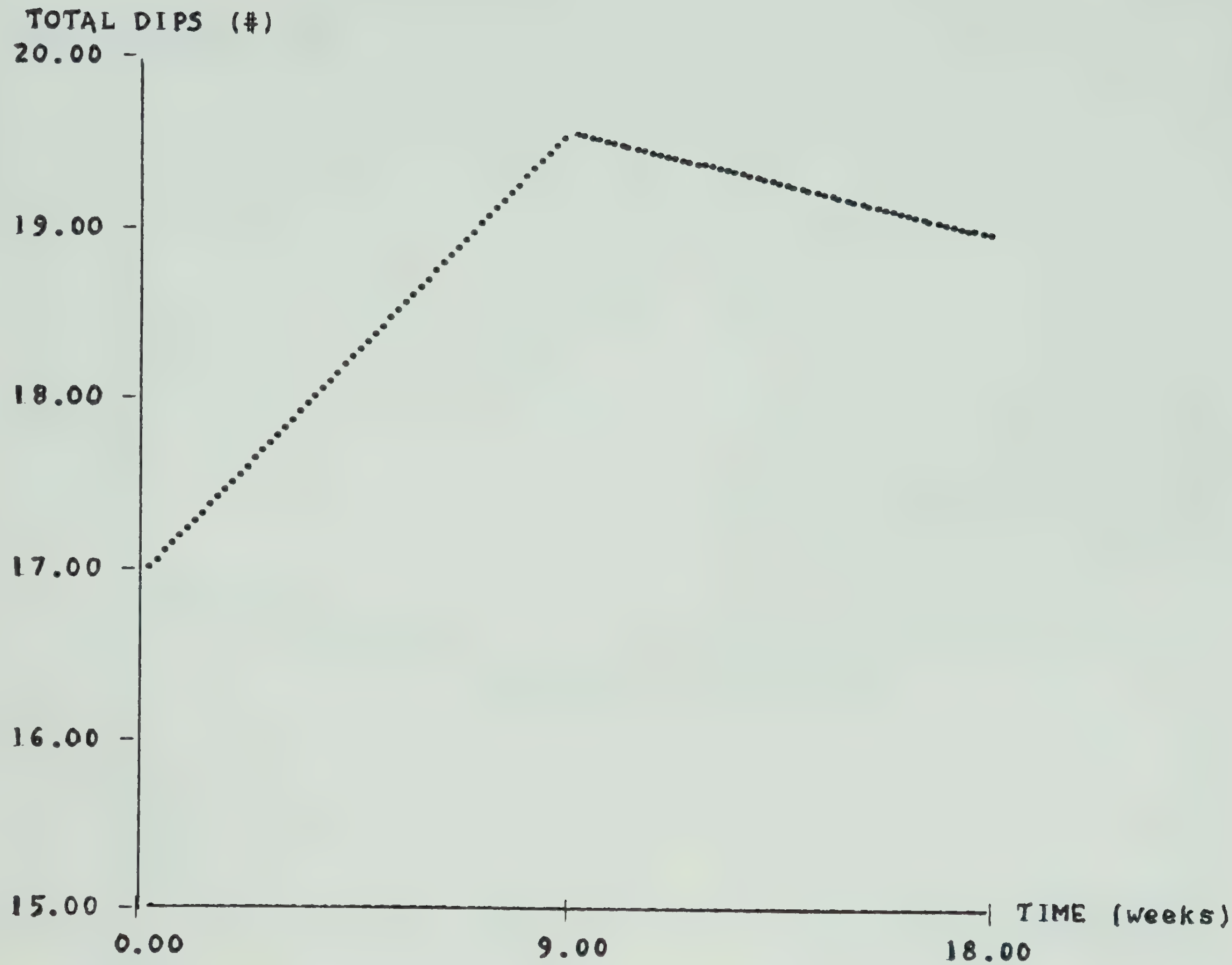

Figure 4.3. Total Dip Changes

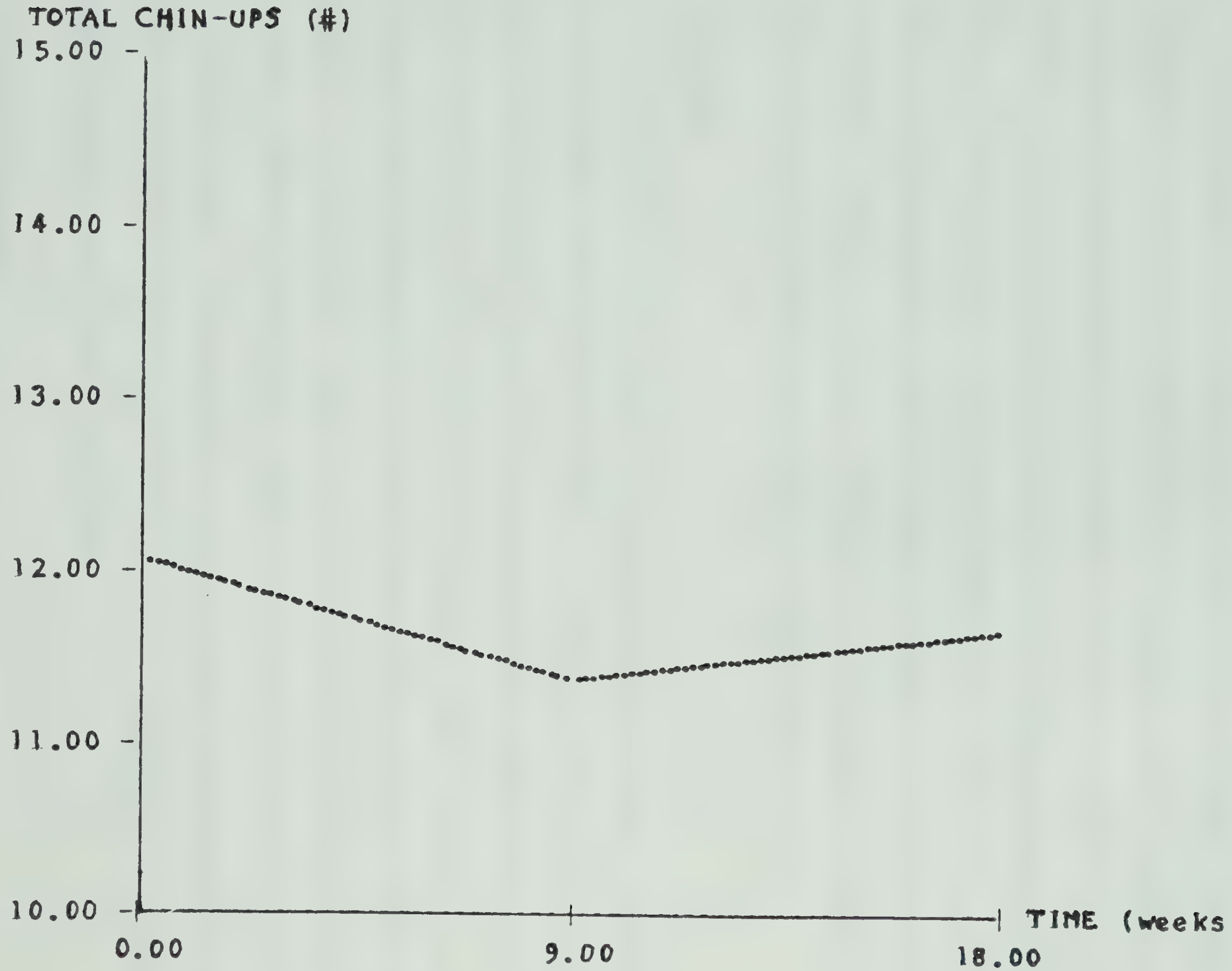

Figure 4.4. Total Chin-up Changes

contain any exercises that stressed the biceps muscle group. Therefore it was not surprising that a change in the chin-up score did not occur.

Standing Long Jump

The standing long jump (SLJ) test was a performance indicator of the subjects' ability to generate lower extremity power (Kirkendall, 1980). The results demonstrated a significant decrease in distance from 96.0 to 92.6 inches at the end of the nine week training period (see Figure 4.5). This particular result was difficult to explain since the circuit training included exercises to develop strength and power in the lower extremity. The SLJ was very difficult to standardize in terms of motivation and possibly this factor had an effect on the result.

Stair Run

The stair run was used to estimate explosive power. There was not a significant change from test one, to test two. The time for the run was essentially the same from the pre-training to post-training tests (see Figure 4.6). This result was somewhat surprising since the fire fighters were required to do stair-running within their circuit training. However, the stair run test involved running two flights of stairs with a corner between each flight, while the training involved running straight flights. Therefore, the subjects were unaccustomed to turning and it appeared that the specific technique required may have been the factor which caused them to lose time.

Agility Shuttle Run

The agility shuttle run time decreased from 12.0 to 11.3 during the nine week training program (see Figure 4.7). Each subject in this test was required to start from a push-up position. Perhaps the push-up and

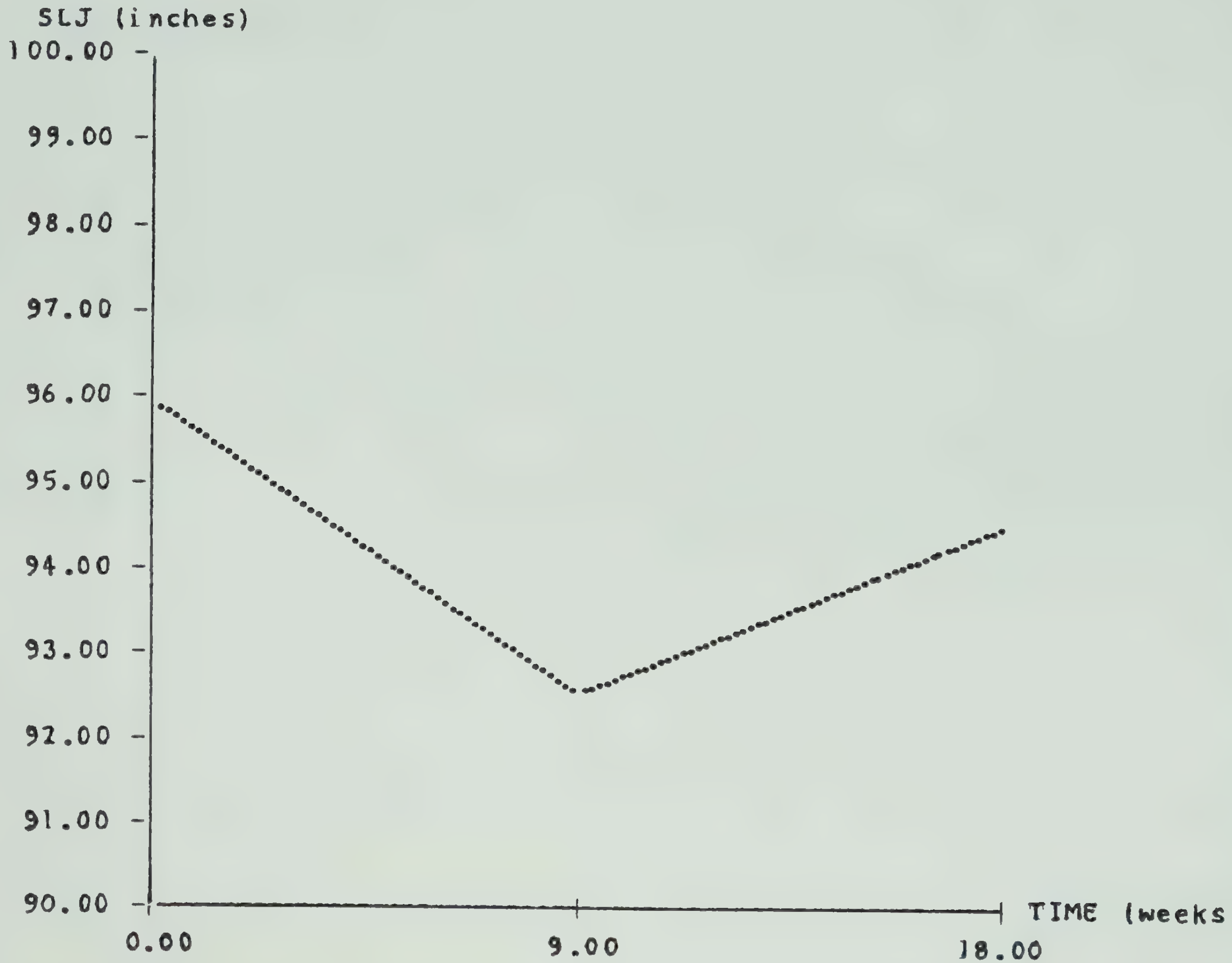

Figure 4.5. Standing Long Jump Changes

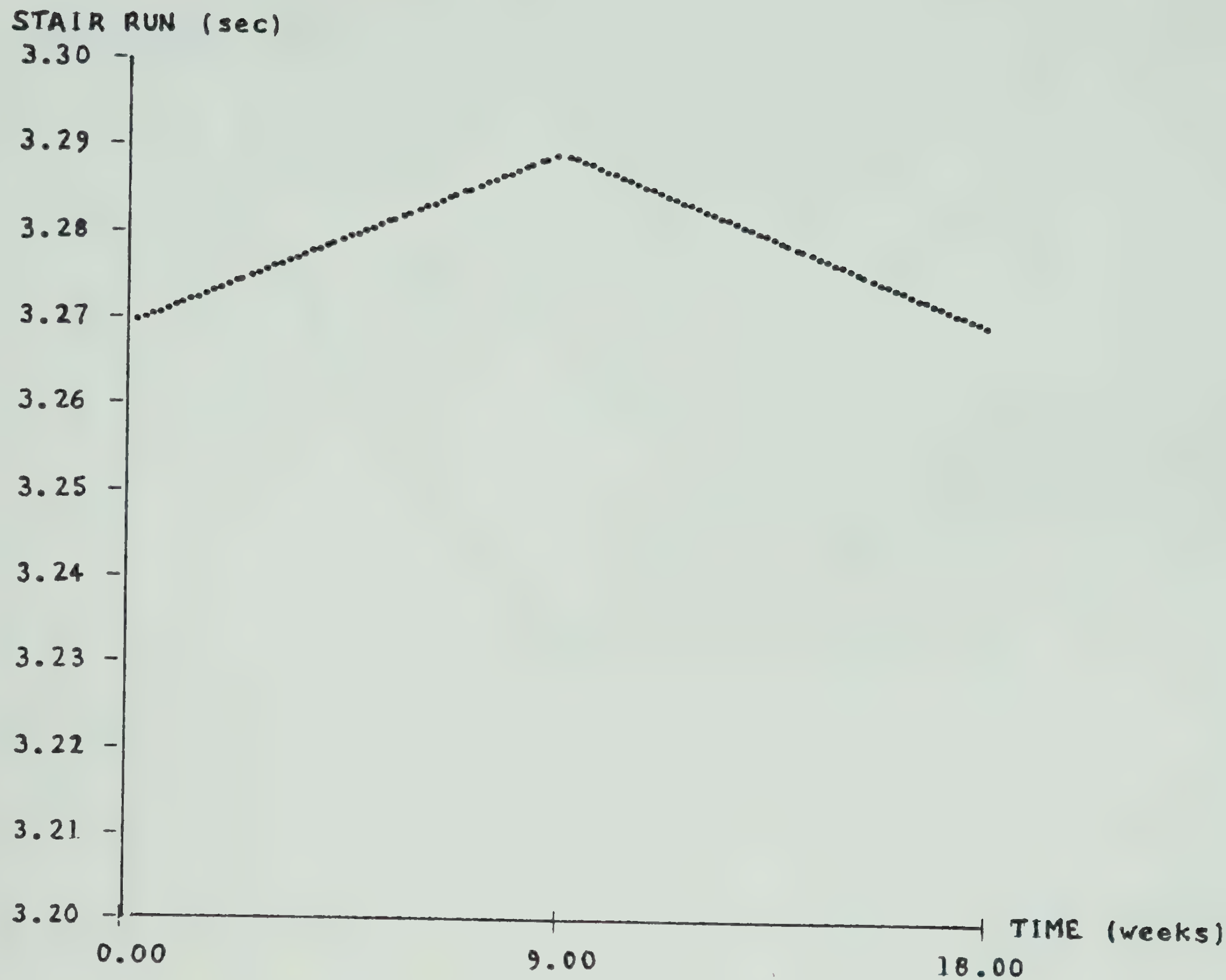

Figure 4.6. Stair Run Changes

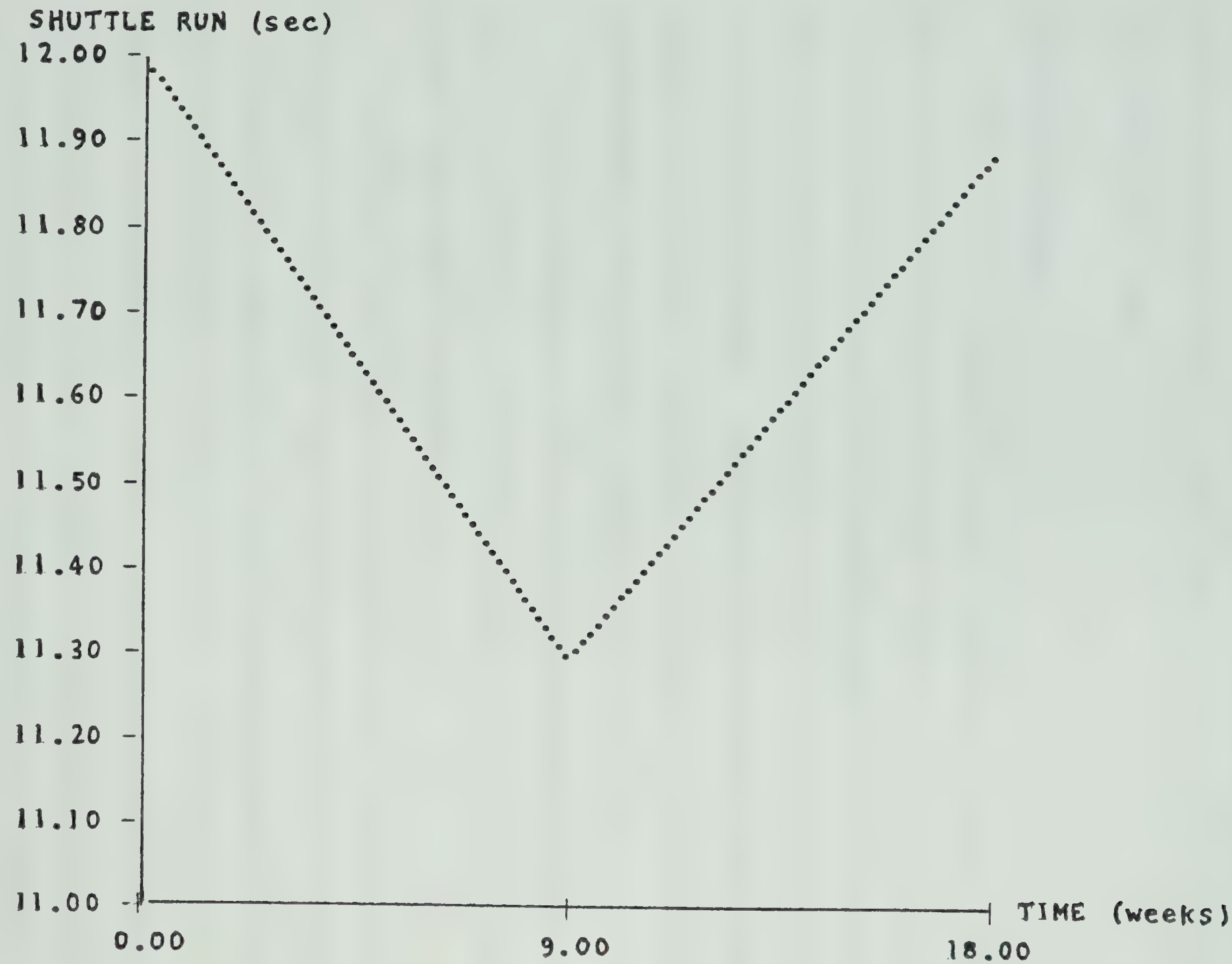

Figure 4.7. Agility Shuttle Run Changes

the burpee-six-count exercises performed in the nine week training program enhanced the subjects' starting ability. Exercises such as the stair-runs, bench hops, and vertical jumps, that were performed in the training program may have developed leg power, which would also help in decreasing the shuttle run time.

Detraining Changes

The detraining changes have been presented in Table 4.1 and Figures 4.3 to 4.7 and will now be briefly discussed.

A significant range in the detraining phase was observed only in the SLJ and the agility shuttle run tests. The SLJ significantly increased from 92.6 to 94.6 inches. This result was unexpected since the SLJ score decreased over the training period. As previously stated, there were problems with the motivation in the SLJ test.

The time increased significantly in the agility shuttle run from 11.3 to 11.9 seconds. This increase could be attributed to the withdrawal of the training stimulus.

As with most performance oriented tests, the influence of motivation may have affected the results of the tests in the present study. For example, the subjects were tested with approximately 150 others potential fire fighter recruits in test one. Due to this highly competitive atmosphere the subjects could have been more highly motivated to perform in the first test as opposed to the latter two tests.

Also, although the functional-performance tests emphasized most of the physical components that a fire fighter would need, perhaps some were not stressed sufficiently during the physical training program. For example, a modified chin-up exercise was included in class 84's training program.

It should also be noted that the training program was designed to maintain or increase the fitness level of the fire fighter, since the people who enter the recruit training program already possess a high level of fitness. Therefore, changes in functional-performance scores were hard to elicit.

BODY COMPOSITION CHANGES

The skinfold technique was used to monitor changes in body composition. This technique provided an estimate of an individual's percent body fat. Body weight was also measured to determine the relationship with the percent body fat changes.

The subjects in Group B (n = 32) were tested before and after their respective nine week training program. The subjects in Group A (n = 23) were tested before and after a nine week period of detraining. Both groups were subjected to a similar training stimulus, although the total duration of Group B's program was slightly less.

A significant decrease in percent body fat from 15.8 to 14.8% (Δ 6.5). was found with no change in body weight during the nine week training program (see Table 4.2). Vogel (1978) also observed a significant decrease in percent body fat (Δ 8.6%) during a 12 week army recruit training period. Again, there was no significant change in body weight. The decrease in body fat with no change indicates an increase in lean tissue.

Wilmore et al. (1970) evaluated the body composition changes as a result of a jogging program of similar duration to the present study (10 weeks). The purpose of the study was to determine the effectiveness of jogging in inducing body composition changes. A small but significant change in body composition was observed. The percent body fat of their subjects dropped from 18.9 to 17.8%.

TABLE 4.2

PERCENT BODY FAT AND WEIGHT CHANGES

Group	Pre-Training T_1 $\overline{X}$	SD	Post-Training T_2 $\overline{X}$	SD	Post-Detraining T_3 $\overline{X}$	SD	Significance $p < .05$ (*)
Group B							
body fat (%)	15.8	4.1	14.8	3.5			*
body wt. (lbs)	172.1	11.1	172.1	10.8			
Group A							
body fat (%)			15.3	4.1	16.2	4.5	*
body wt. (lbs)			164.5	15.7	164.3	15.7	

The present study found a significant increase in percent body fat from 15.3 to 16.2% from test two to test three, with no significant change in body weight. The activity level of the subjects during the detraining period may have decreased sufficiently to reverse the effects of the training program. However, the possibility of increased caloric input cannot be ruled out as another influencing factor.

KNOWLEDGE CHANGES

A knowledge questionnaire was administered to the subjects before and after the fire fighter recruit educational and training classes (Group B) and nine weeks following a period of detraining (Group A). The purpose of the questionnaire was to determine if the average fire fighter becomes more aware of certain topics that they should be particularly concerned with. The questionnaire was designed to assess changes in knowledge in the following areas: physical fitness, training, principles, weight control and nutrition stress, and occupational health risk.

There was a significant increase in the knowledge questionnaire score

from 57.9 to 67.9% over the training period (see Table 4.3). The order of the questions and the multiple choice answers were shuffled but the two tests remained essentially the same. Therefore the subjects appeared to gain some benefit from the lifestyle educational component of the recruit training program. It was possible, however, that some of the questions may have been remembered from the first test.

Group A had a score of 58.9% on the knowledge questionnaire at the end of the detraining period which was not significantly different from the Group B pre-training score (57.9%). If it could be assumed that Group A was not significantly different from Group B at pre-training and some knowledge changes occurred, that by nine weeks the specific information was not retained. It is unknown, however, the extent to which this knowledge change was a result of the educational component of the training program.

GENERAL DISCUSSION

The major purpose of this study was to determine if the nine week training program enhanced physical fitness. The cardiovascular component,

TABLE 4.3

KNOWLEDGE CHANGES

Group	Pre-Training T_1		Post-Training T_2		Post-Detraining T_3		Significance $p < .05$
	$\overline{X}$	SD	$\overline{X}$	SD	$\overline{X}$	SD	*
Group B (%)	57.9	14.7	67.9	10.5			*
Group A (%)					58.9	15.7	

- grade out of 19 represented in percent

specifically $\dot{V}O_2max$, was emphasized as the most important aspect of physical fitness and was stressed in the training program. Body composition has been found to have a strong influence on $\dot{V}O_2max$ (Fox and Mathews, 1976). Therefore, positive changes in $\dot{V}O_2max$ and body composition would help to establish the effectiveness of a physical training program.

Significant alterations in $\dot{V}O_2max$ and body composition have been observed in the subjects of the present study during the nine week training period. Similar observations have been found by other authors (Pollock et al., 1969; Wilmore et al., 1976; and Gettman et al., 1978).

Pollock et al. (1969) observed the effects of interval running and walking on cardiovascular fitness variables and body compositions during a 20 week program. The group of subjects who exercised four times per week demonstrated a 26% increase in $\dot{V}O_2max$. A concomitant significant decrease in body composition from 19.6 to 18.6% body fat was also observed. In comparison the subjects of the present study who exercised five times per week had a 15% increase in $\dot{V}O_2max$. The decrease in percent body fat was similar. The longer total duration (i.e., 20 weeks) and the lower initial fitness level of the subjects in Pollock's study may have caused this difference between the present study.

Gettman et al. (1978) compared a circuit weight training group (CWT) and a continuous running group (CR) in terms of cardiovascular functions, body composition, and strength changes. The subjects trained approximately 25 minutes per day, three times per week for a total duration of 20 weeks. The CR group produced the only significant changes in $\dot{V}O_2max$ from 41.3 to 47.6 $ml.kg^{-1}.min^{-1}$. The CWT produced only a small increase in $\dot{V}O_2max$. The CR group also had a significant decrease in fat weight as opposed to the CWT. The only area where the CWT group surpassed the CR group was in terms of strength gains. However, this result was

not significantly better than the CR group.

The present study had a circuit training component in its training program. This component differed from the CWT group in Gettman's study in that it used muscular strength and endurance exercises as opposed to a universal gym. Both studies emphasized large numbers of repetitions per exercise.

The change in the $\dot{V}O_2max$ was greater in the present study. Some probable reasons could include a greater training intensity and/or a greater frequency of training. Since the present study included an average of 15 minutes of aerobic running and 15 minutes of strength and endurance circuit, it was postulated that the high intensity circuit component may have had a positive influence on $\dot{V}O_2max$.

There was not a significant decrease in $\dot{V}O_2max$ during the nine week period of detraining in the present study. Perhaps the subjects had an increased awareness of the importance of physical fitness that encouraged them to keep up their fitness levels. It should be noted, however, that aerobic fitness is more easily maintained than the rate at which it is gained. Once a particular level of fitness is observed it can be maintained with smaller amounts of training than was required to cause the increase in the first place (Fox, 1979). However, this fitness level can not be maintained indefinitely. It appeared that there was a trend for some of the test values to begin to revert back to post-training levels. Knuttgen et al. (1973) were able to test a number of previous training subjects (trained for 2 months) after an eight month period of detraining. They discovered that their subjects decreased back to original fitness levels.

It was not possible to include a control group in the present study. Therefore, the fitness gains observed were related to the changes between

the individual subjects. In essence the subjects acted as their own controls.

Wenger and MacNab (1975) studied the effect of endurance training on Edmonton fire fighters. They included a control group of 12 subjects in their observation. The $\dot{V}O_2max$ of the control group remained unchanged during the 7 week training program. Other authors have also failed to observe significant changes in $\dot{V}O_2max$ in control subjects as compared to the experimental subjects (Milesis et al., 1970; and Pollock et al., 1969).

CHAPTER V

SUMMARY AND CONCLUSIONS

SUMMARY

The subjects of the present study were fire fighter recruits from the Edmonton Fire Department. Group A consisted of 24 male subjects from class 83 and Group B consisted of 32 male subjects from class 84. Group A was tested before a nine week training program (functional-performance tests), after nine weeks of training (functional-performance and body composition tests), and after a nine week period of detraining (functional-performance, body composition, and general knowledge tests). Group B was tested before a nine week training program (body composition and general knowledge test) and after nine weeks of training (body composition and general knowledge tests).

The physical training program included: flexibility and warm-up exercises, muscular strength and endurance circuit, endurance running and a cool-down period. The program was conducted 50 minutes per day, five times per week for a total duration of nine weeks. The lifestyle educational component of the program included lectures on the following topics: components of fitness and principles of training, development of a personal fitness program, nutrition and weight control, body mechanics, posture and care of the back, physical and psychological demands of fire fighting, lifestyle and health risk, and personal lifestyle planning for fire fighters.

The functional-performance test battery included: $\dot{V}O_2max$, total dips, total chin-ups, standing long jump, stair run, and agility shuttle run tests. Body composition evaluation was made by the assessment of

body fat using a skinfold measurement technique. The general knowledge test was a questionnaire that included nineteen questions from the lifestyle educational resource people.

During the nine weeks of training significant positive changes were observed in $\dot{V}O_2max$, shuttle run, percent body fat, and knowledge questionnaire results. There was a significant decrease in the standing long jump test. The remainder of the test battery result did not change significantly.

The nine week period of detraining produced significant changes in the shuttle run and the standing long jump. The time for the shuttle run increased, as did the long jump distance.

CONCLUSIONS

1. The nine week Edmonton Fire Department physical training program was effective in developing and/or maintaining a high level of physical fitness in fire fighter recruits.
2. The most significant gains were found in cardiovascular fitness, the component which was thought to be the most important for a fire fighter to adequately perform the fire fighter task.
3. The significant positive change in body composition of the average fighter also probably enhanced their aerobic capacity.
4. A noticeable decrease in the fitness gains was not observed in the nine week period of detraining.
5. The lifestyle educational component of the program appeared to elicit positive changes in lifestyle knowledge over the nine week training program but this knowledge was not retained.

RECOMMENDATIONS

1. Further study is needed to determine the long term effectiveness of the training program.
2. Steps should be taken to establish an ongoing training program that would include all the fire fighters now employed by the Edmonton Fire Department.
3. The recruit training program should be continually updated as more insight of the fire fighting task is gained.

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APPENDIX A

FUNCTIONAL-PERFORMANCE TESTS

FUNCTIONAL-PERFORMANCE TESTS

Predicted $\dot{V}O_2$max

The $\dot{V}O_2$max test was used to estimate cardiovascular endurance. The Astrand-Ryhming nomogram (1959) was used to predict the $\dot{V}O_2$max from the heart rate and workload.

apparatus

1. Monarch bicycle ergometers
2. Health-O-Meter weigh scale
3. laboratory timer
4. revolution counter (mico-switch)
5. stethescope
6. stop watch

standardization procedure

1. The bicycle ergometers were calibrated prior to each testing session.
2. The subject was weighed, clan in shorts and socks. The weight was recorded to the closest .5 of a pound.
3. The bicycle seat was adjusted to leg length.
4. The test was described to the subject and a short orientation ride was permitted.
5. The subject then pedalled continuously for eight minutes, four minutes, at 1.5 kilopond resistance (kp) and four minutes at 3.0 kp resistance.
6. The metronome was set at 50 rpms and the revolutions were recorded for the last six minutes.
7. The heart rate was measured by a 30 beat count at the end of the first workload and for each of the last two minutes.
8. The mean of the last two measurements of heart rate were recorded.

Total Dips

The dip test was used only as a performance indicator of upper body strength.

apparatus

1. two parallel bars

standardization procedure

1. The apparatus was designed to allow a subject to descend between two parallel bars to a position of 90 degrees at the elbow.
2. The subject then extended the arms back to the starting position for one complete repetition.
3. The total number of repetitions was recorded.

Total Chin-ups

The chin-up test was also used as a performance indicator of upper body strength.

apparatus

1. a free-swinging horizontal bar, suspended from the ceiling

standardization procedure

1. The subject started from a fully extended arm position.
2. The subject's feet were not allowed to touch the floor at any time.
3. One repetition was recorded each time the chin was brought completely over the bar from a full arm extension.
4. The excessive swinging was controlled by the examiner to keep the exercise specific to upper body movement.
5. The maximum number of repetitions was recorded.

Standing Long Jump

The standing long jump was the performance test used to indicate the subjects' ability to generate lower extremity power.

apparatus

1. measuring tape
2. yardstick to mark the distance

standardization procedure

1. The subjects began with their feet shoulder width apart and with their toes behind the zero mark on the measuring tape.
2. The subjects were encouraged to swing their arms to gather momentum, and jump as far as they could.
3. The examiner marked and recorded (to the nearest .5 of an inch) the longest of two jumps.
4. The distance of the jump was measured from the zero mark on the tape to the back of the closest heel.

Stair Run

A stair run was used as an indicator of explosive power.

apparatus

1. two impulse mats
2. an automatic timer
3. two flights of stairs (11 stairs per flight)

standardization procedure

1. The subject was required to run both flights as quickly as possible triggering the impulse mats at the bottom and top of the run.
2. A single trial was disqualified if the handrail or wall was used for assistance.
3. Two trials were allowed with the fastest time recorded to the nearest .01 of a second.

Agility Shuttle Run

The agility shuttle run was a test of speed and agility.

apparatus

1. two rectangular blocks
2. stop watch

standardization procedure

1. The subject started from a supine position with hands under the shoulders and head behind the starting line.
2. On command, the subject jumped up and ran a distance of 36 feet, picked up the first block, ran back and placed it on the starting line, returned and picked up the second block and sprinted over the finish line.
3. The subject was disqualified if a wall was touched or the block was thrown as opposed to placed on the starting line.
4. The first time of two trials to the nearest .1 of a second was recorded.

APPENDIX B

BODY COMPOSITION ASSESSMENT

BODY COMPOSITION ASSESSMENT

The skinfold technique was used to assess body composition. The sum of skinfolds chart that was used to determine the estimated percent of body fat was first devised by Durnin and Rahaman (1967) and further developed by Durnin and Womersley (1973).

skinfold calipers

The Harpenden skinfold caliper has been found to be a reliable instrument to measure skinfold thickness (Edwards et al., 1952; and Sloan and Shapiro, 1972). The Harpenden calipers were used in this study.

standardization procedure

1. The skinfold sites were located and marked on the right side of the body only.
2. The skinfold was picked up firmly by the thumb and index finger and pulled away from the underlying muscle and facia.
3. The skinfold calipers were placed one centimeter from the fingers.
4. Each site was measured at least twice or until two measurements differed less than 0.4 millimeters.
5. The mean of the closest pair of measurements was recorded.
6. The skinfold measurements were taken in the following order: triceps, biceps, subscapular, and suprailiac.

triceps skinfold

The site was located over the triceps muscle at a point half-way between the acromion and olecronon process. The right arm of the subject was flexed at 90 degrees. The skinfold was measured parallel to the long axis of the upper arm. The subject's arm was extended by the right side of the body in a relaxed state.

biceps skinfold

The site was located over the biceps muscle directly opposite the triceps site. The skinfold was measured parallel to the long axis of the upper arm.

suprailiac skinfold

The site was located approximately two centimeters above the iliac crest at the mid line. The skinfold sloped slightly towards the crest.

subscapula

The site was located approximately two centimeters lateral to the inferior angle of the scapula, at an angle of 45 degrees to the verticle plane.

APPENDIX C

EXAMPLE KNOWLEDGE QUESTIONNAIRE

FIREFIGHTERS QUESTIONNAIRE

1. The best method to decrease the amount of fat in the abdominal area would be to:

    a) reduce the number of calories ingested per day to three hundred.
    b) do fifty or more sit-ups per day
    c) have a surgeon remove the fat
    d) run fifteen minutes or more, three to five times a week.
    e) A & B

2. The "General Adaptation Syndrome" (G.A.S.) describes:

    a) the manner in which a human being develops new coping skills
    b) how an individual can "smile in the face of adversity"
    c) why we feel uneasy when upset.
    d) why we sometimes are unable to react properly to stress
    e) how the body responds to stress.

3. What type of physical activity would be the best to provide a training effect for the cardio-vascular system?

    a) jogging
    b) weight training
    c) cycling
    d) swimming
    e) A, C, or D.

4. What is the most common gaseous hazard at fires?

    a) isocyantes
    b) oxides of nitrogen
    c) carbon monoxide
    d) carbon dioxide
    e) hydrogen cyanide

5. As an adult gets older his/her need for energy (calories) from food usually:

    a) increases and then decreases after age 65
    b) decreases and then increases after age 65
    c) decreases gradually
    d) increases gradually
    e) stays the same.

6. A good way to lose some weight is:

    a) do 10 push-ups per day
    b) to use protein pills
    c) to go on a grapefruit and steak diet
    d) to follow a sensible diet and increase exercise
    e) to go on a fast (not eating) for one day a week.

7. With respect to exercise and training the term aerobic refers to:

   a) high intensity interval training
   b) with oxygen
   c) skeletal muscle strength
   d) physical activity of a long, lower intensity nature which affects the cardiovascular system.
   e) B & D

8. Flexibility exercises are important exercises only if the following principles are considered:

   a) the exercises should be done slowly, utilizing a maximum range of motion
   b) each exercise should be done forcibly in order to get a maximum benefit.
   c) the exercises should be done before and after rigorous activity (ie. running or weight training)
   d) A & C
   e) A & B

9. A warm-up for a normal training session should include:

   a) flexibility exercises
   b) exercises to slightly increase the heart rate
   c) strength and endurance exercises
   d) A & B
   e) all of the above

10. Which of the following are risk factors for coronary heart disease?

   a) high psychological stress
   b) lack of exercise
   c) smoking
   d) poor nutrition
   e) all of the above

11. It is felt that the changes in our traditional values and institutions in recent times:

   a) has created a great uncertainty within us.
   b) has led to a loss of psychological support
   c) has led to a loss of an traditional means of coping with stress.
   d) had left us much more vulnerable to the ravages of stress
   e) all of the above.

12. Lower back pain can often be relieved by:

   a) strengthening the abdominal muscles
   b) increasing the flexibility of the hips and lower back
   c) doing hyperextensor exercises for the lower back
   d) decreasing fat deposites around the abdomen
   e) A, B & D.

13. Stress is defined as:

    a) a reaction to the body to an unpleasant stimulus.
    b) an increase is self-awareness
    c) an alarm reaction
    d) a controlled normal bodily function
    e) an increase in the rate of breathing

14. Symptom(s) of heat related illness include:

    a) fast pounding heart rate
    b) nausea and vomiting
    c) pain in the abdomen, arms, and legs lasting up to three minutes
    d) A & C
    e) all of the above

15. Which is <u>not</u> a common characteristic of a physically fit individual.

    a) less susceptible to weight gain and muscle strain
    b) running long distances every day
    c) absence of fatigue
    d) better sleep habits
    e) greater control of stress situations at home or work.

16. In order for an individual to increase in muscular strength the following principle(s) must be considered:

    a) exercise as frequently as possible
    b) a gradual increase in the amount of weight
    c) a gradual increase in the number of repetitions
    d) B & C
    e) All of the above

17. The subject of potential inhalation hazards in a firefighting environment is complex because:

    a) the number, identity and quantity of different airborne contaminants is difficult to determine.
    b) many gases have poor warning properties
    c) toxic gases may linger after the fire has been extinguished
    d) two gases, relatively harmless when independent of each other may form an extremely toxic contaminant when mixed.
    e) all of the above.

18. In order to get a positive training effect over an eight week period it is necessary to: increase the load every day.

    a) false
    b) true
    c) true only when a plateau is reached
    d) true only with weight training
    e) B & C

19. Foods that are needed daily to help keep a person healthy are:

    a) liver; spinach; fish; and potatoes
    b) milk and milk products; meat and alternatives; fruits and vegetables; and breads and cereals
    c) milk and butter; eggs and fish; porridge and rice; and apples and oranges.
    d) orange juice; meat; milk and bread
    e) honey; yogurt; wheat germ; and alfalfa sprouts.

APPENDIX D

PHYSICAL TRAINING PROGRAM

PHYSICAL TRAINING PROGRAM

The physical training program was for approximately 50 minutes per day, five times per week, for a total of nine weeks. The four phases of the program, a brief description of each phase, and the exercises involved in each phases were as follows.

WARM-UP AND FLEXIBILITY

description

The time allotted for this phase was approximately 10 minutes. The majority of the exercises were encouraged to be done slowly and held for six seconds each. After initial explanation by the instructor, each class member had a turn at leading the class. This procedure was to encourage leadership skills.

exercises

1. neck circles
2. shoulder circles
3. arm circles
4. side bends
5. trunk circles
6. trunk twister
7. back overs
8. quadricepts stretch
9. seated hamstring stretch
10. hurdle stretch
11. groin stretch
12. achilles stretch

Note: before each training session the subjects engaged in approximately 10 minutes of marching.

MUSCULAR STRENGTH AND ENDURANCE CIRCUIT

description

The time allottment for this phase was approximately 15 minutes. Two circuits were designed with three stations per circuit. Circuit A was run on Monday, Wednesday, and Friday and Circuit B on Tuesday and Thursday, of each week. The subjects rotated through the circuits in sequence. The duration of the circuits ranged from 30 seconds initially

to a maximum of 50 seconds. Records were kept of the progress.

exercises

	Circuit A	Circuit B
station I	burpee-six-count abdominal curls push-ups	burpee-six-count abdominal curls push-ups
station II	chest raise v-sits	stair run sit tucks trunk circles
station III	jumping jacks vertical jumps bench hops	jumping jacks vertical jumps side leg raises

AEROBIC OR ENDURANCE COMPONENT

description

The subjects ran a distance that ranged from one to three miles. The average distance covered in each session was approximately 1.5 miles. The subjects monitored their heart rates occasionally but ultimate intensity of the run was left to the discretion of each subject. A criterion run was performed at the end of the third, sixth, and ninth week. Occasionally a swimming session replaced the run.

COOL DOWNS

description

The time allotted for this phase was approximately 10 minutes. The exercises were again led by a class member.

exercises

1. quadriceps stretches
2. hurdler's stretch
3. achilles stretch
4. ankle rotations
5. easy bridge
6. back overs

MODIFICATIONS MADE IN THE PROGRAM BEFORE THE CLASS 84 (GROUP B)

1. Pull-ups were included into the circuit.
2. The exercises were rearranged in the circuit stations so no station over-stressed a particular muscle group.
3. Sprint training occasionally replaced the mile run.

APPENDIX E

ANOVA TABLES

$\dot{V}O_2max$

SOURCE OF VARIATION	SS	DF	MS	F
BETWEEN PEOPLE	0.26187500E+04	23.	0.11385869E+03	
WITHIN PEOPLE	0.25049375E+04	48.	0.52186188E+02	
REPT. MEAS.	0.10851875E+04	2.	0.54259375E+03	17.58
RESIDUAL	0.14197500E+04	46.	0.30864120E+02	
TOTAL	0.51236875E+04	71.		

PROBABILITY OF F = 0.00000 DF=(K-1),(N-1)(K-1)
CONSERVATIVE PROBABILITY = 0.00035 DF=1,(N-1)

THE "CONSERVATIVE PROBABILITY OF F" MAKES ALLOWANCE FOR UNEQUAL COVARIANCES AMONG CORRELATED MEASURES.
SEE WINER,1962, P. 123; 1971, PP. 281-282.

	SINGLE MEASURE	MEAN OF MEASURES
UNADJUSTED RELIABILITIES	0.283	0.542
ADJUSTED RELIABILITIES	0.473	0.729

THE "ADJUSTED RELIABILITIES" REMOVE MEAN DIFFERENCES OF THE K MEASURES AS A SOURCE OF ERROR - EG. BETWEEN JUDGES
SEE "ADJUSTMENT FOR ANCHOR POINTS", WINER, 1971, P. 289; 1962, PP. 128-129.

****

NEWMAN-KEULS COMPARISON BETWEEN ORDERED MEANS
SEE WINER(1962) PAGE 102; 1971, P 217.

ORDERED MEAN DIFFERENCES

		2	3	1
	MEANS	57.604	56.775	48.983
1	48.983	8.621	7.792	0.0
3	56.775	0.829	0.0	
2	57.604	0.0		

R= 3 2

THE MULTIPLIER IS 1.13402

THE MULTIPLIER TIMES THE Q(DF,R) SELECTED PRODUCES MINIMUM MEAN DIFFERENCE TO ACHIEVE SIGNIFICANCE
Q HAS THE DF OF MS ERROR (RESIDUAL)

Q-VALUES FOR MEAN DIFFERENCES

		2	3	1
	MEANS	57.604	56.775	48.983
1	48.983	7.602	6.871	0.0
3	56.775	0.731	0.0	
2	57.604	0.0		

CONSULT TABLE C.4, P870, WINER(1971)

Total Dips

SOURCE OF VARIATION	SS	DF	MS	F
BETWEEN PEOPLE	0.24129883E+04	23.	0.10491252E+03	
WITHIN PEOPLE	0.73466797E+03	48.	0.15305582E+02	
REPT. MEAS.	0.87031250E+02	2.	0.43515625E+02	3.09
RESIDUAL	0.64763672E+03	46.	0.14079059E+02	
TOTAL	0.31476563E+04	71.		

PROBABILITY OF F = 0.05502 DF=(K-1),(N-1)(K-1)
CONSERVATIVE PROBABILITY = 0.09204 DF=1,(N-1)

THE "CONSERVATIVE PROBABILITY OF F" MAKES ALLOWANCE FOR UNEQUAL COVARIANCES AMONG CORRELATED MEASURES.
SEE WINER,1962, P. 123; 1971, PP. 281-282.

	SINGLE MEASURE	MEAN OF MEASURES
UNADJUSTED RELIABILITIES	0.661	0.854
ADJUSTED RELIABILITIES	0.683	0.866

THE "ADJUSTED RELIABILITIES" REMOVE MEAN DIFFERENCES OF THE K MEASURES AS A SOURCE OF ERROR - EG. BETWEEN JUDGES
SEE "ADJUSTMENT FOR ANCHOR POINTS", WINER, 1971, P. 289; 1962, PP. 128-129.

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NEWMAN-KEULS COMPARISON BETWEEN ORDERED MEANS
SEE WINER(1962) PAGE 102; 1971, P 217.

ORDERED MEAN DIFFERENCES

		2	3	1
	MEANS	19.583	19.083	17.042
1	17.042	2.542	2.042	0.0
3	19.083	0.500	0.0	
2	19.583	0.0		

R= 3 2

THE MULTIPLIER IS 0.76592

Q-VALUES FOR MEAN DIFFERENCES

		2	3	1
	MEANS	19.583	19.083	17.042
1	17.042	3.318	2.666	0.0
3	19.083	0.653	0.0	
2	19.583	0.0		

CONSULT TABLE C.4, P870, WINER(1971)

Total Chin-ups

SOURCE OF VARIATION	SS	DF	MS	F
BETWEEN PEOPLE	0.40910938E+03	23.	0.17787354E+02	
WITHIN PEOPLE	0.12533594E+03	48.	0.26111650E+01	
REPT. MEAS.	0.68593750E+01	2.	0.34296875E+01	1.33
RESIDUAL	0.11847656E+03	46.	0.25755768E+01	
TOTAL	0.53444531E+03	71.		

PROBABILITY OF F = 0.27403 DF=(K-1),(N-1)(K-1)
CONSERVATIVE PROBABILITY = 0.26037 DF=1,(N-1)

THE "CONSERVATIVE PROBABILITY OF F" MAKES ALLOWANCE FOR UNEQUAL COVARIANCES AMONG CORRELATED MEASURES.
SEE WINER,1962, P. 123; 1971, PP. 281-282.

	SINGLE MEASURE	MEAN OF MEASURES
UNADJUSTED RELIABILITIES	0.660	0.853
ADJUSTED RELIABILITIES	0.663	0.855

THE "ADJUSTED RELIABILITIES" REMOVE MEAN DIFFERENCES OF THE K MEASURES AS A SOURCE OF ERROR - EG. BETWEEN JUDGES
SEE "ADJUSTMENT FOR ANCHOR POINTS", WINER, 1971, P. 289; 1962, PP. 128-129.

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NEWMAN-KEULS COMPARISON BETWEEN ORDERED MEANS
SEE WINER(1962) PAGE 102; 1971, P 217.

ORDERED MEAN DIFFERENCES

		1	3	2
	MEANS	12.125	11.667	11.375
2	11.375	0.750	0.292	0.0
3	11.667	0.458	0.0	
1	12.125	0.0		

R= 3 2

THE MULTIPLIER IS 0.32759

Q-VALUES FOR MEAN DIFFERENCES

		1	3	2
	MEANS	12.125	11.667	11.375
2	11.375	2.289	0.890	0.0
3	11.667	1.399	0.0	
1	12.125	0.0		

CONSULT TABLE C.4, P870, WINER(1971)

Standing Long Jump

SOURCE OF VARIATION	SS	DF	MS	F
BETWEEN PEOPLE	0.15443125E+04	23.	0.67144012E+02	
WITHIN PEOPLE	0.77193750E+03	48.	0.16082031E+02	
REPT. MEAS.	0.15650000E+03	2.	0.78250000E+02	5.85
RESIDUAL	0.61543750E+03	46.	0.13379076E+02	
TOTAL	0.23162500E+04	71.		

PROBABILITY OF F = 0.00546 DF=(K-1),(N-1)(K-1)
CONSERVATIVE PROBABILITY = 0.02391 DF=1,(N-1)

THE "CONSERVATIVE PROBABILITY OF F" MAKES ALLOWANCE FOR UNEQUAL COVARIANCES AMONG CORRELATED MEASURES.
SEE WINER,1962, P. 123; 1971, PP. 281-282.

	SINGLE MEASURE	MEAN OF MEASURES
UNADJUSTED RELIABILITIES	0.514	0.760
ADJUSTED RELIABILITIES	0.573	0.801

THE "ADJUSTED RELIABILITIES" REMOVE MEAN DIFFERENCES OF THE K MEASURES AS A SOURCE OF ERROR - EG. BETWEEN JUDGES
SEE "ADJUSTMENT FOR ANCHOR POINTS", WINER, 1971, P. 289; 1962, PP. 128-129.

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NEWMAN-KEULS COMPARISON BETWEEN ORDERED MEANS
SEE WINER(1962) PAGE 102; 1971, P 217.

ORDERED MEAN DIFFERENCES

		1	3	2
	MEANS	96.021	94.750	92.458
2	92.458	3.563	2.292	0.0
3	94.750	1.271	0.0	
1	96.021	0.0		

R= 3 2

THE MULTIPLIER IS 0.74663

Q-VALUES FOR MEAN DIFFERENCES

		1	3	2
	MEANS	96.021	94.750	92.458
2	92.458	4.771	3.069	0.0
3	94.750	1.702	0.0	
1	96.021	0.0		

CONSULT TABLE C.4, P870, WINER(1971)

Stair Run

ROW 1 0.199 0.189 0.185

SOURCE OF VARIATION	SS	DF	MS	F
BETWEEN PEOPLE	0.19306641E+01	23.	0.83941877E-01	
WITHIN PEOPLE	0.60009766E+00	48.	0.12502033E-01	
REPT. MEAS.	0.46386719E-02	2.	0.23193359E-02	0.18
RESIDUAL	0.59545898E+00	46.	0.12944758E-01	
TOTAL	0.25307617E+01	71.		

PROBABILITY OF F = 0.83654 DF=(K-1),(N-1)(K-1)
CONSERVATIVE PROBABILITY = 0.67602 DF=1,(N-1)

THE "CONSERVATIVE PROBABILITY OF F" MAKES ALLOWANCE FOR UNEQUAL COVARIANCES AMONG CORRELATED MEASURES.
SEE WINER,1962, P. 123; 1971, PP. 281-282.

	SINGLE MEASURE	MEAN OF MEASURES
UNADJUSTED RELIABILITIES	0.656	0.851
ADJUSTED RELIABILITIES	0.646	0.846

THE "ADJUSTED RELIABILITIES" REMOVE MEAN DIFFERENCES OF THE K MEASURES AS A SOURCE OF ERROR - EG. BETWEEN JUDGES
SEE "ADJUSTMENT FOR ANCHOR POINTS", WINER, 1971, P. 289; 1962, PP. 128-129.

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NEWMAN-KEULS COMPARISON BETWEEN ORDERED MEANS
SEE WINER(1962) PAGE 102; 1971, P 217.

ORDERED MEAN DIFFERENCES

		2	1	3
	MEANS	3.288	3.272	3.265
3	3.265	0.023	0.007	0.0
1	3.272	0.016	0.0	
2	3.288	0.0		

R= 3 2

THE MULTIPLIER IS 0.02322
Q-VALUES FOR MEAN DIFFERENCES

		2	1	3
	MEANS	3.288	3.272	3.265
3	3.265	0.987	0.305	0.0
1	3.272	0.682	0.0	
2	3.288	0.0		

CONSULT TABLE C.4, P870, WINER(1971)

Shuttle Run

ROW 1 0.935 0.491 1.727

SOURCE OF VARIATION	SS	DF	MS	F
BETWEEN PEOPLE	0.39507813E+02	23.	0.17177305E+01	
WITHIN PEOPLE	0.62367188E+02	48.	0.12993164E+01	
REPT. MEAS.	0.76875000E+01	2.	0.38437500E+01	3.23
RESIDUAL	0.54679688E+02	46.	0.11886883E+01	
TOTAL	0.10187500E+03	71.		

PROBABILITY OF F = 0.04853 DF=(K-1),(N-1)(K-1)
CONSERVATIVE PROBABILITY = 0.08528 DF=1,(N-1)

THE "CONSERVATIVE PROBABILITY OF F" MAKES ALLOWANCE FOR UNEQUAL COVARIANCES AMONG CORRELATED MEASURES.
SEE WINER,1962, P. 123; 1971, PP. 281-282.

	SINGLE MEASURE	MEAN OF MEASURES
UNADJUSTED RELIABILITIES	0.097	0.244
ADJUSTED RELIABILITIES	0.129	0.308

THE "ADJUSTED RELIABILITIES" REMOVE MEAN DIFFERENCES OF THE K MEASURES AS A SOURCE OF ERROR - EG. BETWEEN JUDGES
SEE "ADJUSTMENT FOR ANCHOR POINTS", WINER, 1971, P. 289; 1962, PP. 128-129.

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NEWMAN-KEULS COMPARISON BETWEEN ORDERED MEANS
SEE WINER(1962) PAGE 102; 1971, P 217.

ORDERED MEAN DIFFERENCES

		1	3	2
	MEANS	12.029	11.892	11.279
2	11.279	0.750	0.612	0.0
3	11.892	0.138	0.0	
1	12.029	0.0		

R= 3 2

THE MULTIPLIER IS 0.22255
Q-VALUES FOR MEAN DIFFERENCES

		1	3	2
	MEANS	12.029	11.892	11.279
2	11.279	3.370	2.752	0.0
3	11.892	0.618	0.0	
1	12.029	0.0		

CONSULT TABLE C.4, P870, WINER(1971)

APPENDIX F

RAW DATA

FUNCTIONAL-PERFORMANCE TESTS: RAW DATA

Subject #	$\dot{V}O_2max$ $ml.kg^{-1}.min^{-1}$			Total Dips rep			Total Chin-ups rep			Standing Long Jump in			St. Run sec			Agility SH. Run sec		
	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
01	50.2	71.6	64.9	19	15	16	14	10	13	89.5	85.0	92.0	3.33	3.57	3.68	12.0	11.6	19.8
02	39.0	51.1	57.0	9	11	11	7	6	7	96.5	86.0	94.0	3.18	3.36	3.56	11.2	11.5	11.6
03	48.2	49.5	59.9	21	15	16	12	11	10	89.5	80.0	87.0	3.23	3.25	3.32	12.6	11.6	12.4
04	41.5	52.3	50.9	25	20	18	14	12	12	97.0	83.0	95.0	3.12	3.06	3.08	11.2	11.2	11.4
05	52.1	52.3	55.8	12	11	12	7	10	8	93.0	80.0	90.0	3.26	3.20	3.32	13.9	11.7	11.7
06	43.1	48.3	55.4	15	19	17	11	13	10	102.5	90.0	94.0	3.10	3.19	3.09	11.0	11.1	10.8
07	59.0	74.3	64.2	12	11	8	15	14	8	88.0	92.0	94.0	3.28	3.38	3.36	14.1	12.2	11.6
08	45.3	60.5	53.2	17	24	21	13	12	12	101.5	97.0	99.0	3.12	3.18	3.09	12.0	11.2	11.5
09	68.3	59.1	56.6	13	8	10	10	7	9	95.0	94.0	92.0	3.32	3.35	3.31	11.4	11.0	12.0
10	45.5	69.8	68.0	15	15	13	14	12	13	98.5	99.0	95.0	3.11	2.95	3.09	11.8	10.9	11.2
11	41.7	45.4	41.7	15	15	14	8	5	9	99.0	103.0	101.0	3.34	3.40	3.45	11.4	11.0	11.7
12	45.2	47.3	52.2	13	15	19	10	5	11	92.0	95.0	97.0	3.28	3.17	3.13	14.0	11.3	11.8
13	49.0	54.0	51.5	19	28	25	15	14	15	102.5	100.0	104.0	3.13	3.40	3.13	12.6	10.8	11.6
14	43.7	58.7	52.6	16	18	13	14	13	12	102.0	90.0	95.0	3.18	3.24	3.29	12.4	11.8	11.9
15	39.6	49.8	55.8	12	16	23	10	10	11	97.0	103.0	101.0	3.01	3.08	3.11	11.4	11.6	10.9
16	64.4	58.1	57.8	19	28	24	11	11	11	103.0	93.0	95.0	3.30	3.16	3.11	11.9	10.8	11.3
17	50.2	57.0	56.3	18	29	26	12	16	18	98.0	93.0	93.0	3.10	3.03	3.11	11.3	11.0	11.5
18	45.4	53.7	47.6	26	38	46	14	14	15	93.5	93.0	91.0	3.82	3.72	3.51	11.3	12.3	11.8

FUNCTIONAL-PERFORMANCE TESTS: RAW DATA

Subject #	$\dot{V}O_2max$ $ml.kg^{-1}.min^{-1}$			Total Dips rep			Total Chin-ups rep			Standing Long Jump in			St. Run sec			Agility SH. Run sec		
	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
19	51.8	70.1	70.4	14	23	20	16	16	15	89.0	90.0	92.0	3.34	3.34	3.24	12.2	10.3	11.3
20	50.1	54.9	58.1	20	21	13	13	12	13	106.0	104.0	99.0	3.09	3.11	3.04	11.7	11.0	11.5
21	48.3	66.3	52.3	16	26	25	11	11	12	88.0	88.0	93.0	3.53	3.38	3.29	11.9	10.9	11.2
22	52.8	65.4	68.4	24	25	29	14	12	12	99.0	96.0	102.0	3.29	3.24	3.20	11.3	11.1	11.4
23	50.6	58.3	68.3	16	20	20	13	16	14	89.0	92.0	92.0	3.78	3.51	3.25	13.1	12.0	12.3
24	50.6	54.7	43.7	22	19	19	13	11	10	95.5	93.0	87.0	3.30	3.57	3.51	11.0	10.8	11.2
25	42.2	58.3		19	7		11	10		89.5	89.0		3.12	3.23		11.6	11.4	
26	43.4	58.1		34	37		14	14		100.0	90.6		3.73	3.18		13.7	11.0	
27	48.1	59.9		19	16		14	12		91.0	90.0		3.27	3.55		12.4	11.8	
28	46.6	57.5		10	11		13	12		93.5	88.0		3.34	3.36		12.4	11.6	
29	43.1	56.6		20	22		17	14		97.0	99.0		3.01	2.92		11.2	10.7	
30	35.0	54.4		17	20		15	10		98.0	95.0		3.09	3.03		11.8	11.2	
31	41.4	56.4		18	18		15	11		93.5	93.0		3.20	3.32		12.1	11.8	
32	54.2	59.9		15	15		16	8		98.5	90.0		3.35	3.25		11.6	10.7	
33	43.7	55.4		22	16		12	11		99.0	94.0		3.09	3.26		11.6	11.3	
34	51.9	61.5		18	9		15	13		88.5	84.0		3.45	3.55		12.6	12.8	
35	43.1	47.3		36	42		16	16		90.0	89.0		3.29	3.23		11.9	11.1	
36	50.0	69.4		10	18		6	7		90.5	88.0		3.42	3.38		12.8	11.7	

BODY WEIGHT AND PERCENT FAT: RAW DATA

Group B Subject #	Weight lb T_1	Weight lb T_2	Body Fat % T_1	Body Fat % T_2	Group A Subject #	Weight lb T_1	Weight lb T_2	Weight lb T_3	Body Fat % T_2	Body Fat % T_3
37	158.0	156.0	11.7	9.3	01	159.0	160.0	157.0	13.8	11.7
38	159.5	157.5	12.9	13.8	02	219.5	210.0	205.5	23.5	22.2
39	156.5	161.0	12.9	12.9	03	157.0	162.5	159.5	17.7	18.3
40	175.5	176.0	21.2	19.5	04	163.0	164.5	167.0	16.4	19.0
41	162.0	162.5	12.9	13.8	05	146.0	158.0	158.5	16.4	15.5
42	182.5	174.0	20.6	15.5	06	169.0	177.0	178.0	16.4	21.2
43	173.5	176.0	10.5	11.7	07	151.0	150.0	149.0	11.7	12.9
44	187.0	193.5	16.4	13.8	08	151.5	151.0	150.5	11.7	10.5
45	170.5	170.5	13.8	12.9	09	165.0	170.5	174.5	17.0	21.2
46	154.0	154.0	11.7	11.7	10	162.0	167.0	171.0	11.7	14.7
47	170.5	173.5	8.1	8.1	11	180.5	185.0	185.0	14.5	19.5
48	184.0	182.0	24.8	22.2	12	172.0	178.5	184.5	24.8	24.0
49	166.5	171.0	16.4	17.0	13	131.0	135.0	134.5	8.1	8.1
50	175.5	180.0	12.9	12.9	14	168.5	172.0	169.5	13.8	12.9
51	185.5	174.5	18.3	16.4	15	171.0	165.5	168.0	11.7	12.9
52	172.5	178.2	14.7	16.4	16	145.0	139.0	144.1	17.0	21.2
53	173.0	171.0	12.9	11.7	17	146.0	152.0	148.0	8.1	9.3
54	142.0	142.0	16.4	13.8	18	162.0	167.0	160.5	14.7	12.9
55	169.5	176.0	15.5	15.5	19	149.0	152.0	151.5	12.9	12.9
56	166.0	163.5	14.7	13.8	20	165.0	169.5	168.5	15.5	18.3
57	202.0	199.5	15.5	13.8	21	159.0	156.0	154.0	13.8	16.4
58	170.5	165.0	23.1	20.6	22	173.0	175.0	174.0	16.4	17.7
59	163.5	169.0	17.7	19.5	23	174.0	166.0	165.5	18.3	19.5
60	156.0	156.5	13.8	12.9						
61	168.5	166.0	19.0	19.0						
62	181.5	176.0	19.0	17.0						
63	161.0	165.0	12.9	14.7						
64	179.5	175.5	25.8	22.6						
65	179.5	182.0	13.8	12.9						
66	165.5	165.5	13.8	10.5						
67	172.5	166.5	18.3	13.8						
68	174.0	174.0	13.8	12.9						

KNOWLEDGE QUESTIONNAIRE: RAW DATA

Group B	T_1		T_2		Group A	T_3	
#	Grade	19	Grade	19	#	Grade	19
37	9		11		1	7	
38	10		13		2	11	
39	8		12		3	13	
40	11		12		4	6	
41	6		13		5	12	
42	9		14		6	13	
43	15		15		7	10	
44	9		16		8	13	
45	13		13		9	18	
46	13		14		10	14	
47	9		11		11	16	
48	9		11		12	14	
49	11		13		13	8	
50	8		15		14	13	
51	9		11		15	13	
52	8		11		16	13	
53	13		11		17	11	
54	12		14		18	11	
55	13		12		19	14	
56	15		16		20	11	
57	12		13		21	18	
58	8		14		22	15	
59	7		10		23	10	
60	16		12		24	9	
61	14		16				
62	12		13				
63	13		14				
64	8		13				
65	12		8				
66	11		13				
67	15		17				
68	10		11				

CRITERION RUN: RAW DATA

Group A	3rd week	6th week	9th week	Group B	Pre Training	3rd week	6th week	9th week
01	6:16	5:51	5:53	37	5:57	5:43	5:29	5:11
02	6:45	6:13	5:58	38	6:04	6:00	5:46	5:37
03	6:05	5:44	5:43	39	6:14	6:01	5:58	5:50
04	5:36	5:37	5:32	40	6:08	6:09	5:53	5:35
05	5:32	-	5:42	41	6:01	5:54	5:39	5:27
06	6:25	6:04	5:43	42	5:44	5:53	5:38	5:26
07	5:44	5:39	5:33	43	6:06	6:01	5:54	5:46
08	6:02	5:48	5:34	44	5:26	5:23	5:08	4:59
09	5:52	5:48	5:40	45	5:50	5:47	5:39	5:24
10	6:17	6:08	6:09	46	5:16	5:12	5:06	5:02
11	5:51	5:31	5:23	47	5:51	5:53	5:40	5:27
12	6:42	6:25	6:16	48	6:42	6:21	6:10	6:08
13	6:00	5:48	5:36	49	5:47	5:40	-	5:28
14	6:00	5:49	5:36	50	6:56	6:50	6:35	5:58
15	5:39	5:20	5:02	51	5:54	5:51	5:29	5:20
16	5:30	5:24	5:15	52	6:19	6:38	6:21	5:55
17	5:51	5:24	5:21	53	6:07	5:58	5:43	5:75
18	6:14	5:58	5:51	54	5:46	5:44	5:40	5:26
19	5:45	5:27	5:22	55	5:56	5:36	5:23	5:15
20	6:50	6:20	6:11	56	5:31	5:30	5:13	5:07
21	5:26	5:18	5:07	57	5:53	5:50	5:31	5:28
22	5:57	5:49	5:41	58	5:59	5:56	-	5:32
23	5:31	5:32	5:26	59	5:20	5:19	5:14	5:02
24	6:39	6:19	6:11	60	5:35	5:41	5:29	5:12
				61	7:06	6:43	6:26	6:11
				62	5:20	5:20	5:28	5:12
				63	5:21	5:19	5:13	5:01
				64	6:25	6:28	6:01	6:00
				65	6:12	6:11	6:04	5:52
				66	6:06	5:54	5:42	5:30
				67	6:23	6:11	-	5:58
				68	6:24	6:19	6:04	5:58